Final report

OWMC
Ontario
Waste Management
Corporation

A provincial crown corporation.

Gartner
Lee
Associates
Limited

SITE SELECTION PROCESS
PHASE 3B: SELECTION OF CANDIDATE SITES
PHYSICAL RESOURCES

FOR

ONTARIO WASTE MANAGEMENT CORPORATION

BY

GARTNER LEE ASSOCIATES LIMITED

OCTOBER, 1984

Gartner Lee Associates Limited

Consulting Engineering
Geologists
Biologists and
Hydrogeologists

Toronto-Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-477-8400
Telex-06-986278

October 15, 1984.

Ontario Waste Management Corporation,
2 Bloor Street West,
11th Floor,
Toronto, Ontario,
M4W 3E2.

Attention: Dr. B.D. Mitchell, Director
Corporate Planning and Development

Dear Sirs:

Re: Phase 3 Technical Report - Physical Resources

We are pleased to submit our report titled "Site Selection Process, Phase 3B: Selection of Candidate Sites, Physical Resources". This report identifies and describes physical resource factors used during Phase 3B of OWMC's Site Selection Process and demonstrates their application during this Phase.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED

E.G. Anderson, P.Eng.,
Consulting Hydrogeologist,
Project Director.

EGA:jcm
Enclosure.

TABLE OF CONTENTS

	PAGE
LETTER OF TRANSMITTAL	
TABLE OF CONTENTS	(i)
PHYSICAL RESOURCE STUDY TEAM	(vii)
EXECUTIVE SUMMARY	(viii)
1.0 INTRODUCTION	1
1.1 BACKGROUND	1
1.2 PURPOSE AND SCOPE	3
1.3 SITE SELECTION PRINCIPLES	6
1.4 GOALS AND OBJECTIVES	9
1.5 FACILITY AND WASTE CHARACTERISTICS	11
1.6 STATUS OF DATA	16
2.0 IDENTIFICATION OF SITE AREAS	19
2.1 BACKGROUND	19
2.2 FACTOR IDENTIFICATION AND METHODOLOGY	20
2.3 PHYSICAL RESOURCES FACTORS - CONSTRAINT MAPPING	23
2.4 FACTOR RANKING AND APPLICATION	38
2.5 OTHER CONSTRAINT MAPPING CONSIDERATIONS	41
2.6 CONCLUSIONS AND RECOMMENDATIONS	46
3.0 IDENTIFICATION OF POTENTIAL SITES	48
3.1 BACKGROUND	48
3.2 FACTOR IDENTIFICATION	49
3.3 FACTOR DESCRIPTIONS AND RATIONALE	54
3.4 DATA COLLECTION	63
3.5 FACTOR APPLICATION AND SITE AREA RANKING	64
3.6 CONCLUSIONS AND RECOMMENDATIONS	77

		PAGE
4.0	IDENTIFICATION OF CANDIDATE SITES	80
4.1	BACKGROUND	80
4.2	FACTOR IDENTIFICATION	82
4.3	FACTOR DESCRIPTIONS AND RATIONALE	82
4.4	DATA COLLECTION	84
4.5	FACTOR APPLICATION	88
4.6	SITING OPTIONS RANKING	95
4.7	CONCLUSIONS AND RECOMMENDATIONS	98
5.0	REFERENCES AND BIBLIOGRAPHY	101

APPENDICES

APPENDIX A - FACTOR SHEETS.

APPENDIX B - IDENTIFICATION OF POTENTIAL SITES

APPENDIX C - IDENTIFICATION OF CANDIDATE SITES (SUMMARY DESCRIPTIONS OF THE GEOLOGY AND HYDROGEOLOGY OF THE POTENTIAL SITES)

APPENDIX D - IDENTIFICATION OF CANDIDATE SITES (ACCESS ROUTE ANALYSIS)

APPENDIX E - SURFACE DRAINAGE REPORT PREPARED BY M.M. DILLON LIMITED

PAGE

FIGURES

1. CANDIDATE AREAS WITHIN THE SELECTED GEOGRAPHIC REGION 2

2. SITE IDENTIFICATION FACTORS AND MAJOR ACTIVITIES UNDERTAKEN FOR PHYSICAL RESOURCES COMPONENTS 5

3. SCHEMATIC CROSS-SECTION OF CLAY-SILT/WENTWORTH TILL RELATIONSHIP 27

4. POTENTIAL SITES FROM WHICH CANDIDATE SITES WERE SELECTED 81

APPENDIX B

B-1 FIELD OBSERVATION SUMMARY - GEOLOGY B-1

B-2 FIELD OBSERVATION SHEET - GEOLOGICAL STATIONS B-3

B-3 PHYSICAL RESOURCE FEATURES - LF-4 WEST B-5

APPENDIX C

C-1 PHYSICAL RESOURCE FEATURES - LF-2 NORTH C-3

C-2 PHYSICAL RESOURCE FEATURES - LF-4 NORTH C-5

C-3 PHYSICAL RESOURCE FEATURES - PI-1A1 C-7

C-4 PHYSICAL RESOURCE FEATURES - PI-1 NORTH C-9

C-5 PHYSICAL RESOURCE FEATURES - PI-13 NORTH C-11

C-6 PHYSICAL RESOURCE FEATURES - LF-10a WEST C-13

C-7 PHYSICAL RESOURCE FEATURES - LF-10b WEST C-14

C-8 PHYSICAL RESOURCE FEATURES - LF-11 WEST C-16

C-9 PHYSICAL RESOURCE FEATURES - PI-2 WEST C-18

C-10 PHYSICAL RESOURCE FEATURES - LF-1 CENTRAL C-20

C-11 PHYSICAL RESOURCE FEATURES - LF-3 CENTRAL C-22

C-12 PHYSICAL RESOURCE FEATURES - LF-8 CENTRAL C-25

C-13 PHYSICAL RESOURCE FEATURES - LF-9 CENTRAL C-28

C-14 PHYSICAL RESOURCE FEATURES - LF-1a EAST C-31

FIGURES (CONT'D)

		PAGE
C-15	PHYSICAL RESOURCE FEATURES - LF-1B EAST	C-32
C-16	PHYSICAL RESOURCE FEATURES - LF-3 EAST	C-35
C-17	PHYSICAL RESOURCE FEATURES - PI-18 EAST	C-38
C-18	PHYSICAL RESOURCE FEATURES - PI-27 EAST	C-41

THE FOLLOWING FIGURES FOR CONSTRAINT MAPPING ARE PRESENTED IN THE TECHNICAL DATA MAP PORTFOLIO

G-PR1	PHYSICAL RESOURCE FEATURES - NORTH
G-PR2	PHYSICAL RESOURCE FEATURES - WEST
G-PR3	PHYSICAL RESOURCE FEATURES - CENTRAL
G-PR4	PHYSICAL RESOURCE FEATURES - EAST

TABLES

1. SITE SELECTION PRINCIPLES IDENTIFIED IN THE INTERIM PHASE 3 REPORT 7

2. PHYSICAL RESOURCE SITE SELECTION OBJECTIVES IDENTIFIED IN THE OWMC PHASE 3 REPORT, MARCH, 1984 12

3. SUMMARY OF PHYSICAL RESOURCE FACTORS AND THEIR SIGNIFICANCE TO FACILITY SITING 39

4. CENTRAL AREA ROUTE ASSESSMENT PHYSICAL RESOURCE CONSIDERATIONS 45

PAGE

LIST OF TABLES (CONT'D)

5. SITE AREAS SCREENED 50

6. RANKING SYSTEM USED IN IDENTIFICATION OF POTENTIAL SITES 67

7. IDENTIFIED CONSTRAINTS IN SITE AREAS 69

8. RANKING OF SITE AREAS 75

9. RANKING SYSTEM USED IN IDENTIFICATION OF CANDIDATE SITES - NATURAL CONTAINMENT POTENTIAL FACTOR 89

10. OIL AND GAS WELL CONSIDERATIONS 91

11. RANKING OF POTENTIAL SITES BASED ON THE NATURAL CONTAINMENT POTENTIAL FACTOR 92

12. PRINCIPAL SOURCES OF GROUND WATER SUPPLIES (AQUIFERS) IN THE VICINITY OF THE POTENTIAL SITES 94

13. RANKING SYSTEM USED IN DIFFERENTIATING AMONGST SITING OPTIONS 96

14. RANKING OF SITING OPTIONS 97

APPENDIX B

B-1 SUMMARY OF SITE AREA CHARACTERISTICS AND RANKING (LANDFILL/INTEGRATED FACILITIES) B-6

B-2 SUMMARY OF SITE AREA CHARACTERISTICS AND RANKING (PHYSICAL/CHEMICAL TREATMENT AND INCINERATOR FACILITIES) B-8

TABLES (CONT'D)

PAGE

APPENDIX D

D-1 ACCESS ROUTE ANALYSIS D-1

APPENDIX E

E-1 OWMC - SURFACE DRAINAGE EVALUATION

E-2 FACTOR RATING

PHYSICAL RESOURCES STUDY TEAM

This study was carried out under the direction of Grant Anderson, Project Director, Gartner Lee Associates Limited (GLAL). The study team consisted of:

Donald McQuay - Senior Earth Scientist of GLAL - Terrain Evaluation

Andrew Cooper - Senior Geologist of GLAL - Quaternary Geology Interpretation

Gunther Funk - Senior Hydrogeologist of GLAL - Hydrogeology Interpretation

Alan Mitchell - Branch Manager, Environmental Engineering and Science of M.M. Dillon Limited, Consulting Engineering Planners and Environmental Scientists - Surface Drainage Interpretation during Identification of Candidate Sites.

EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

- To identify and describe physical resource factors (geology, physical terrain, hydrogeology and surface drainage) used during Phase 3B of OWMC's Site Selection Process, and to demonstrate their application during this Phase.

- To document how the physical resources factors were utilized to assist OWMC in selecting candidate sites.

SCOPE AND METHODS

- The physical resource factors were among numerous multidisciplinary factors used to attain goals and objectives of OWMC's "Site Selection Process".

- A "desk top" analysis of geology, hydrogeology, surface drainage and physical terrain conditions of the 20 candidate areas, 90 site areas and 16 potential sites was undertaken using publicly available information. This analysis was augmented by observations made during road side visits to the site areas and potential sites.

- During the first stage (identification of site areas) physical resource maps were prepared depicting the results of flood plain mapping, soil maps and an airphoto interpretation of surficial ground conditions. These maps are based on analysis at a 1:50,000 scale and are presented in the Technical Data Map Portfolio.

- The information collected during the second stage (identification of potential sites) and the third stage (identification of candidate sites) was tabulated and the site areas and potential sites were ranked qualitatively according to the perceived level of natural containment provided by the local hydrogeologic setting.

PREMISES AND POSTULATES

- The Ontario Waste Management Corporation (OWMC) Phase 3 Interim Report (May, 1983) identified candidate areas and possible facility components that might be sited in each candidate area.

- The number, location and boundaries of the candidate areas, site areas and potential sites to be evaluated during Phase 3B were determined by OWMC in consultation with their site selection consulting team.

- Site selection goals established by OWMC in consultation with their site selection consultants are in order of priority:

  (i) to minimize risk to human health,
  (ii) to minimize environmental impacts,
  (iii) to minimize financial costs.

  These goals were taken into consideration in identification, ranking and application of the physical resources factors.

- The analysis would use only the existing data base and such information as is publicly available or could be readily obtained during a road side site visit. Detailed site evaluation is to be conducted later, in Phase 4.

- During identification of site areas, those physical resource features which may present major constraints to facility development would be identified.

- A ranking system would be developed for the physical resource factors that would assist OWMC in the comparison between site areas and between potential sites.

STATUS OF DATA

- The data base used in this analysis is largely regional in scope. This information is suitable for identification of candidate sites. More detailed site and site vicinity work will be required to verify the interpretation of site conditions provided in this study during Phase 4 (see Section 1.6 of report).

MAIN FINDINGS

- Information on geology, physical terrain conditions, surface drainage and hydrogeology which may influence site selection and development is documented for 20 candidate areas, 90 of 152 site areas and 16 potential sites (Sections 2, 3 and 4 respectively).

IDENTIFICATION OF SITE AREAS

- Ten physical resource factors were identified and mapped during constraint mapping. Individual factor sheets are provided in Appendix A and the geographic distribution of these factors is shown in Maps G-PR1 to G-PR4 in the Technical Data Map Portfolio.

- Five factors are associated with major constraints necessitating reliance on engineering to contain potential contaminants and thus are not likely to provide the desired second level of protection. These are:

    - surface granular soil,
    - stream course,
    - flood plain,
    - wetland,
    - drumlin (Niagara).

  Potential risks to human health and potential impacts on the environment may result if facilities are developed on lands containing these features. These negative attributes are contrary to the fundamental site selection principles and goals discussed in Sections 1.3 and 1.4.

- Two factors -- drumlin field and moraine, may contain variable subsurface conditions. While it is possible that portions of these lands may contain uniform, fine-grained soils, the likelihood of finding such areas, even after detailed site drilling, is considered low relative to other features. As such, consistent with the "Likelihood of Suitability" principle, less priority was given to these two features and they have been considered as exclusionary at this time.

- Three physical resource factors have been identified as non-exclusionary. These are:

i) till and lacustrine clay plain,
ii) drumlin (Halton),
iii) poor surface drainage.

The first two factors have uniform predictable characteristics. The natural attributes of these factors should naturally restrict the movement of contaminants. Strict reliance on engineering to minimize risk to human health and impact on the environment would not likely be required.

- The third factor, poor surface drainage, may require some mitigative measures. These could be as simple as facility placement to avoid the feature, to modification of surface drainage conditions during site development. No major hydrogeologic constraints were identified. Inasmuch as this feature is associated with deep, uniform clay-textured soils, retaining these areas for further analysis contributed to diversity of choice.

IDENTIFICATION OF POTENTIAL SITES

- A total of 90 of the 152 site areas identified as a result of the constraint mapping process were evaluated using physical resource considerations.

- Of these, thirty-eight (38) may potentially be considered for an integrated facility or a landfill.

- Twelve (12) of the 38 integrated landfill site areas were ranked as "Level 1" site areas (Table 8, Section 3.5), 14 were ranked as "Level 2" and 12 were ranked as "Level 3".

- Of the 90 site areas, 52 may potentially be considered for a chemical treatment plant and/or incinerator.

- Sixteen (16) of the 52 physical/chemical treatment and incinerator site areas were ranked as "Level 1" (Table 8, Section 3.5), 27 were ranked as "Level 2" and 9 were ranked as "Level 3".

- Some portions of the site areas contained constraints that should be considered exclusionary. These are spoil piles, moraines, stream courses and flood plains. Table 7, Section 3.5 summarizes the site areas affected and maps on file with OWMC depict the specific features. Re-routing of stream courses could serve to mitigate the surface drainage concerns.

IDENTIFICATION OF CANDIDATE SITES:

- a total of 17 siting options (includes 16 potential sites and alternative access routes) were evaluated;

- of these, 2 siting options were ranked as "Level 1", 5 as "Level 2" and 9 as "Level 3" (Section 4.6);

- one site - LF-3E was ranked as "Major Constraint". This site is underlain by less than the 20 m minimum of fine textured soil thickness used as a general guideline for landfilling. LF-1E located close by LF-3E was preferred over LF-3E because the clay soils appeared to be deeper.

CONCLUSIONS AND RECOMMENDATIONS

IDENTIFICATION OF SITE AREAS

- The three non-exclusionary physical resources factors described are:

  i) till and lacustrine clay plain
  ii) drumlin (Halton)
  iii) poor surface drainage

- The distribution of these factors in the Golden Horseshoe candidate areas is depicted in Maps G-PR1 to G-PR4 Technical Data Map Portfolio. These figures should be used in conjunction with the Hydrogeology Map contained in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report by Gartner Lee Associates Limited (GLAL), 1984, and the OWMC Interim Phase 3 Report, May 1983 to identify potentially acceptable site areas for locating various facilities. Reference is made to Section 2.1 of this report for a brief discussion of the significant hydrogeologic results from the two above mentioned reports.

  - The landfill should potentially be sited on Category 1A, 1B and 2A lands (see GLAL, 1984) that have not been excluded as a result of the physical resource constraint mapping (identification of site areas) studies described in this report.

  - The physical chemical treatment plant and/or the incinerator should potentially be sited on all Category 1 and 2 lands (see GLAL, 1984) that have not been excluded as a result of the physical resource contraint mapping (identification of site areas) studies described in this report.

IDENTIFICATION OF POTENTIAL SITES

- The site area ranking information contained in Table 8 Section 3.5 should be utilized in conjunction with information gathered by other consultants to further reduce the size and number of site areas.

- Lands within the site areas containing constraints identified in Table 7, Section 3.5 should be excluded for facility placement. Where this results in poor site area configuration, or insufficient site area size, the site area should be excluded.

- On those sites that are carried forward into the third stage (Identification of Candidate Sites) more detailed site assessments should be carried out.

- Some portions of the site areas contain constraints that should be considered exclusionary. These are spoil piles, moraines, stream courses and flood plains. Table 7, Section 3.5 summarizes the site areas affected and maps on file with OWMC depict the specific features.

IDENTIFICATION OF CANDIDATE SITES

- The siting option ranking information contained in Table 14, Section 4.6 should be utilized in conjunction with information gathered by other consultants to select candidate sites.

- Site LF-3E was ranked as "Major Constraint" because the confining layer thickness appears to be much less than 20 m and should be excluded from further consideration at this time. Site LF-1E was preferred over LF-3E because the clay appeared to be deeper.

- To maintain a diversity of choice, siting options that were ranked as "Level 1' "Level 2" and "Level 3" should be maintained in the final list of candidate sites. Further, sites located over a diversity of aquifers (Table 12) should be maintained in the final list of candidate sites.

- More detailed on-site testing of the candidate sites, including soil sampling using drilling techniques, would be required during subsequent stages to confirm interpretations contained in this report. This drilling program should be integrated with site interview information obtained through discussion with local residents and other knowledgeable individuals, and with agencies, municipalities and public interest groups.

1.0 INTRODUCTION

1.1 BACKGROUND

The Ontario Waste Management Corporation has implemented a phased "Facilities Development Process" to establish facilities for the treatment and disposal of hazardous and liquid industrial wastes in the Province. The search for a suitable site(s) is an important component of the overall process.

In May 1983, the Phase 3 Interim Report of the Ontario Waste Management Corporation (OWMC) indicated that 19 candidate areas in the Golden Horseshoe had been identified for further evaluation in the process of selecting a site or sites for facilities to treat and dispose of special wastes. In January 1984, one additional candidate area was identified east of Brampton as a result of an intensive hydrogeologic and geologic search in the Toronto (Area A-1) study area (Gartner Lee Associates Limited (GLAL) Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region, 1984) - the lands stretching easterly from Brampton to Oshawa. The candidate areas are shown on Figure 1.

To further narrow the candidate areas down to smaller, more discrete candidate sites, the distribution of a number of biophysical, land use, social, planning, engineering and agricultural factors was mapped within the candidate areas. Factors were chosen according to their influence on the basic goals identified below, in order of priority.

Figure 1 Candidate Areas Within the Selected Geographic Region

Source: Ontario Waste Management Corporation, March 1984

Legend — Components Included

- Physical/Chemical Treatment Plant Only
- Engineered Landfill & Physical/Chemical Treatment Plant
- Physical/Chemical Treatment Plant & Incinerator
- Integrated - All Components

Miles 0 10 Kilometers 0 10

NOTE: Candidate Area Numbers are shown on the physical resource features maps.

1. To minimize risk to human health;
2. to minimize environmental impact; and
3. to minimize financial cost to OWMC.

A more detailed discussion of these goals and objectives is contained in Section 1.4.

The physical resource factor grouping is one of the major groupings under consideration in narrowing the study area from candidate areas to a short list of candidate sites. The physical resource factor grouping encompasses geology, physical terrain, hydrogeology and surface drainage.

The various factors of the physical resource grouping which are considered important in achieving OWMC's site selection goals are identified in this report. Also provided is a discussion of the significance of these factors to facility siting and the methodology employed in their application during each stage of Phase 3B.

For an understanding of the role of other factors in the site selection process, the reader is referred to individual technical reports on biology, planning, etc. and to the technical report which describes the overall site selection process prepared for the Ontario Waste Management Corporation by M.M. Dillon Limited.

1.2 PURPOSE AND SCOPE

Physical resources (geology, physical terrain, hydrogeology and surface drainage) studies were undertaken by Gartner Lee Associates Limited in support of OWMC's Phase 3B site selection

process. Phase 3B was divided into three major stages.

- the identification of smaller areas called "site areas" within the larger candidate areas by a mapping technique called constraint mapping (Section 2.0);

- the reduction of site areas in number and size to "potential sites" by a process called site screening (Section 3.0); and

- the reduction of tne list of potential sites to a short list of candidate sites by a process called initial comparative evaluation (Section 4.0).

Figure 2, following, depicts the three stage process adopted to identify candidate sites within the 20 candidate areas. The physical resource factors utilized at each stage and the major activities are briefly outlined to provide a general overview of the physical resource study scope. Details for each of the three stages are contained in Sections 2, 3 and 4 of this report.

This report describes the following aspects of the site selection process related to the physical resource factors.

1. The basic principles that guided the application of the physical resource factors in the site selection process are described in Section 1.3.

2. The goals and objectives established by OWMC, its staff, the public and consultants related to the physical resource considerations are discussed in Section 1.4.

GOLDEN HORSESHOE REGION
20 CANDIDATE AREAS

IDENTIFICATION OF SITE AREAS (CONSTRAINT MAPPING)	
FACTORS	**MAJOR ACTIVITIES UNDERTAKEN**
Till and Lacustrine Clay Plain Drumlin (Halton) Drumlin (Niagara) Drumlin Field Moraine Surface Granular Soil Poor Surface Drainage Wetlands Flood Plain Stream Course	- Mapping of major physical terrain features and conditions of the 20 Candidate Areas at a scale of 1:50,000 - Input to the identification of Site Areas

IDENTIFICATION OF POTENTIAL SITES (SITE SCREENING)	
FACTORS	**MAJOR ACTIVITIES UNDERTAKEN**
Natural Containment Potential Aquifer Surface Drainage	- Assessment of geologic, hydrogeologic and physical terrain conditions for 152 Site Areas at a scale of 1:50,000 and 90 Site Areas at a scale of 1:10,000 - Input to the identification of Potential Sites

IDENTIFICATION OF CANDIDATE SITES (INITIAL COMPARATIVE EVALUATION)	
FACTORS	**MAJOR ACTIVITIES UNDERTAKEN**
Natural Containment Potential Aquifer Surface Drainage Sensitive Lands (Access Route Analysis)	- Refinement of geologic, hydrogeologic and physical terrain interpretation for 16 Potential Sites at scales of 1:50,000 and 1:10,000 - Input to the identification of Candidate Sites

FIGURE 2: SITE IDENTIFICATION FACTORS AND MAJOR ACTIVITIES UNDERTAKEN FOR PHYSICAL RESOURCES COMPONENT

3. The physical resource factors, utilized to address the goals and objectives including a rationale for each factor's significance are described for each of the three stages of the site selection process.

4. The results of the three major stages of investigation -- constraint mapping, site screening and initial comparative evaluation are described in Sections 2.0, 3.0 and 4.0 respectively.

5. An executive summary is contained at the front of this report, briefly describing the Phase 3B physical resource study results.

1.3 SITE SELECTION PRINCIPLES

A number of site selection principles were identified in the OWMC Interim Phase 3 report. Table 1 contains a summary of these principles and the following paragraphs describe how the site selection principles were incorporated into the physical resource study program.

i) Progressive Refinement of the Search Process: A three stage site selection process was utilized. Broad regional information was used during the initial stage, and more site specific information was used during the latter stages as the search narrowed from the twenty large candidate areas to the eight candidate sites.

ii) Definition of the Environment: From a physical resources perspective, emphasis was placed on assessing the pathways through which contaminants could migrate. This necessitated studying the terrain, geology, hydrogeology and surface drainage.

TABLE 1: SITE SELECTION PRINCIPLES IDENTIFIED IN THE OWMC INTERIM PHASE 3 REPORT

i) Progressive Refinement of the Search Process:	The process must evolve in a series of steps, which involve the evaluation of alternatives and the narrowing of geographic focus.
ii) Definition of the Environment:	The very broad and inclusive definition of the environment used in the Ontario Environmental Assessment Act (1975) has been adopted by OWMC. The environmental impact assessment process embodied in this Act also has been adopted by OWMC.
iii) Protection of Human Health and the Environment:	The primary consideration must be protecting human health and the environment.
iv) The Involvement of Those Affected:	Affected agencies, organizations and people must be consulted at key decision points in the process. OWMC is committed to a thorough consultation process.
v) Efficiency and Effectiveness of the Process:	The costs and time involved in conducting a detailed analysis and evaluation of every conceivable site across the Province are prohibitive. The search and selection process must focus available resources systematically on critical concerns and reach definite conclusions as quickly as possible.
vi) A Second Natural Level of Protection of the Environment:	A second level of protection of the environment beyond that provided for by the design and operating procedures of the facility component is essential.
vii) Likelihood of Suitability:	Because the factors addressed at this stage are at a broad regional scale, the suitability of a selected candidate area can be expressed at this stage only as a likelihood or probability of suitability subject to later, more detailed investigation.
viii) The Maintenance of Choice:	As decisions are made, there must be the assurance at each step of the process that no significant or unique alternatives are being discarded absolutely.

iii) Protection of Human Health and the Environment: OWMC's goal is to minimize risk to human health and minimize impact on the environment. As such, physical resource factors were identified and discussed with respect to their significance for facility siting, at each stage of the process, according to their ability to protect human health and the environment.

iv) The Involvement of Those Affected: The physical resource study team was involved in the extensive public consultation program. The concerns raised during this program were utilized to assist in factor ranking and trade-off considerations. In addition agency contacts were made during Phase 3B, and the release of this report will form the basis of further discussions with agencies, organizations and individuals.

v) Efficiency and Effectiveness of the Process: The scope of studies by the physical resource study team was designed to take into consideration the scale of the area being studied and the resources available to undertake the assessments in a reasonable time frame. It is recognized that any uncertainties associated with the nature of our data base would ultimately be determined by detailed on-site studies once preferred sites are selected.

vi) Second Level of Protection: Engineering design and operating procedures are intended to minimize risks to human health and impacts on the environment. The physical resource study team incorporated factors in the selection process that permitted the control of potential contaminants by the natural site setting. Thus, in the event of accidental spills or leaks the site's physical setting would naturally contain contaminants and protect human health and the environment.

vii) Likelihood of Suitability: The physical resource study team recognized that the ultimate determination of site acceptability would depend on detailed site specific testing programs to be undertaken during Phase 4. To optimize the likelihood of confirming the acceptability of the preferred sites during the subsequent Phase 4 studies, priority was given to terrain features and sites which offered a greater potential for proving to be suitable. As such any sites dropped from the list should be considered temporarily excluded until the site selection process is completed.

viii) The Maintenance of Choice: The physical resource study team recognized the need to maintain a variety of site hydrogeologic settings. This will ensure that trade-offs associated with other factor groupings could be adequately dealt with during subsequent phases of the selection process.

1.4 GOALS AND OBJECTIVES

The site selection goals and objectives were developed through the OWMC consulting team discussions, input from OWMC staff and expressed concerns by the public and agencies.

Three site selection goals were identified in order of priority, these are

1) minimize risk to human health;
2) minimize environmental impacts;
3) minimize financial costs to OWMC and the public.

A more detailed description of the goals and objectives is contained in the Phase 3B site selection technical report prepared by M.M. Dillon Limited. Considerations associated with

the physical resource studies carried out during Phase 3B are presented in this report.

In order to minimize risk to human health and minimize environmental impact, it is necessary to assess the "pathways" through which contaminants might move. From a physical resources perspective, the transportation medium is the subsurface geologic setting and/or the surface drainage system.

As an example, the link to human health effects stems from the possibility of contaminants migrating through the geologic materials into the well water supply of an adjacent property. Similarly, contaminants migrating through ground water that discharges into a local creek could affect the ecosystem of the creek i.e. aquatic life (fish).

Although the first line of defence at OWMC's facilities will be the facility design and operational procedures, the physical resource studies place priority on factors that will provide a second level of protection to ground water and surface water resources and will provide adequate lead time to mitigate problems in the event of engineering failure.

Little emphasis was placed on physical resource factors as they affect costs during Phase 3B. It is recognized that, until detailed site specific studies are completed during Phase 4, costs cannot be accurately determined. Having regard to the fact that site hydrogeologic design concepts will likely be similar for the various facilities on all sites, only minor cost differences for site development are expected.

Drainage considerations during the identification of candidate sites did incorporate a cost component; however, this was

used only to flag those potential risks which may require relatively greater site drainage improvements.

A number of objectives were developed which are pertinent to physical resource considerations in the site selection process. These objectives are listed in Table 2.

1.5 FACILITY AND WASTE CHARACTERISTICS

1.5.1 BACKGROUND

The assumptions relating to the facility and waste characteristics are outlined in the GLAL report titled Hydrogeologic Considerations for Facilities Siting dated May 1983. This information has been reviewed, edited and presented here for completeness.

Information on the facility characteristics is not presently finalized, although study by others is currently underway. GLAL did, however, make a number of preliminary assumptions that guide the physical resource study team in developing a hydrogeologic rationale.

The study team understands that all OWMC facilities will incorporate proven technologies to the extent possible. While it is possible to engineer safeguards which will greatly reduce the possibility of spills or leaks, OWMC does not wish to rely completely on these engineered systems to protect the environment. While engineered systems will be utilized at all sites, the final defense will be the natural capability of the physical environment to accommodate the possibility of leaks and spills.

Monitoring for contaminant release will be an integral part of all facilities operations and this monitoring will trigger

TABLE 2: PHYSICAL RESOURCE SITE SELECTION OBJECTIVES IDENTIFIED IN THE PHASE 3 REPORT, MARCH, 1984

I) GOAL

To select a site(s) in a manner which minimizes risk to human health.

OBJECTIVES

A. Site - "Pathways" into the Environment

1. To site facility components in hydrogeologic settings that will restrict naturally the movement of contaminants and protect ground water resources, and to utilize engineering measures where required to ensure maximum environmental safety.

2. To site facility components in hydrogeologic settings that will restrict naturally the movement of contaminants and protect human health, surface water resources and aquatic ecosystems.

3. To site facility components in settings that minimize the hazards to the site as a result of such conditions as flooding, potential susceptibility to seismic disturbance, and to utilize engineering measures where required to ensure maximum environmental safety.

4. To site facility components in settings which facilitate environmental monitoring as well as the application of countermeasures, including backup emergency services.

B. Site - Human Exposure

1. To site facility components to minimize the potential for the contamination of existing wells and other sources of water for human and animal consumption.

C. Transportation and Discharge - "Pathways" into the Environment

1. To site facility components so that the physical settings along the access routes to the site(s) naturally restrict the movement of contaminants and protect human health, terrestrial and aquatic ecosystems.

II) GOAL

To select a site(s) in a manner which minimizes environmental impacts.

OBJECTIVES

A. Physical and Biological

1. To minimize physical impacts on surface water such as sedimentation and changes in base flow.

2. To minimize impacts on surface water quality from emissions.

TABLE 2-(PAGE 2)

OBJECTIVES (continued)

3. To avoid destruction and minimize disruption of significant natural ecosystems.

B. Resources

1. To minimize displacement and disruption to other natural resource uses such as mineral aggregates.

III) GOAL

To minimize financial costs to OMMC.

Objectives

A. To minimize capital and operating costs to the greatest extent possible without sacrificing environmental quality.

1. To minimize on-site development costs, e.g. clearing, drainage, grading, screening and other engineering modifications.

2. To minimize development and/or operations cost necessitated by site or area characteristics, e.g. special remedial or monitoring measures to protect human health and the environment.

activation of contingency measures. Such contingency planning measures will be aimed at rapid response and clean-up in the event of accidental spills or leaks.

1.5.2 ENGINEERED LANDFILL

In a landfill, residues from the treatment processes are intentionally and permanently placed on or below the ground surface. The landfill will accept only treated residues which will be primarily inorganic in nature.

The possibility that waste residues will be solidified to provide structural integrity of the product and to minimize the production of leachate is under active consideration. For the purpose of this report it has been assumed that residues have been solidified.

During the disposal operations, waste residues will be placed in individual cells of limited capacity. This will help to ensure that incompatible wastes are isolated from each other, that the wastes are compatible with engineered components such as liners if one is needed, that the working area is of manageable size and that the facility design can be modified to accommodate future technological advances and contingency plans.

The engineered landfill will be designed to minimize the formation of leachate, sited to retard migration of any leachate into the surrounding environment and designed to provide remedial contingency measures, if needed.

In order to realize these design objectives, perpetual maintenance and monitoring of the landfill facility will be required.

As a consequence of the Hydrogeologic Considerations Report, 1983 GLAL established a general preference for siting the landfill in hydrogeologic settings that are uniform, predictable

and fine-grained. For planning purposes about 20 m or greater of silt-clay soils are preferable.

1.5.3 TREATMENT AND TRANSFER FACILITIES

These facilities include the physical/chemical treatment plant, the incinerator and possibly various transfer stations to be established in the Province. Transfer facility siting is deferred until a later stage of the investigations. Unlike the landfill, raw wastes will be handled, stored and treated at these facilities for only a finite length of time, this time being governed by the active life of the facility. No wastes (treated or untreated) will be disposed below the ground at these sites unless the facility is fully integrated.

Treatment components and handling methods will be compatible with the waste streams and will be designed to minimize environmental exposure. Quality and quantity control supervision and monitoring will verify the composition of the waste loads received, determine the appropriate treatment processes and control the quality of processing. Site specific spill containment features could include pads, berms and drainage collection installations.

The physical/chemical treatment facility will handle and treat a wide range of wastes consisting primarily of heavy metal solutions and residuals. However, it has been indicated that oil/water mixtures, organic and oily residuals, and paint and organic residuals could also be treated at the physical/chemical treatment plant.

The organic compounds, following initial treatments, will be transferred to the incinerator. The incinerator will handle and treat or destroy primarily organic compounds such as organic

and oily residuals, sludges, still bottoms and paints. Metal sludges, slags and residues (inorganic in nature), following solidification, would go to the landfill. Treated waste streams would either be discharged to a suitable receiver or transferred to the physical/chemical treatment plant for further processing.

The transfer stations will handle, store and possibly bulk both organic and inorganic wastes.

Data available at the present time indicate that organic constituents could be present in the liquid effluents from the various facilities. The type, quantity and characteristics of the constituent organics are as yet unknown.

For planning purposes, sites with about 10 m of fine textured soil conditions or greater are preferred for the physical/chemical treatment and incinerator facilities.

The treatment processes are presently being assessed as are the emissions characteristics. Once these assessments are complete, the physical resource site selection implications will be reassessed.

1.6 STATUS OF DATA

A number of points about the data associated with this analysis should be identified.

First, the data base used at all three stages of the selection process is largely regional. As an example, Ministry of the Environment computer print outs of water well records and well plot maps current to December 1980 were used in our analysis.

These records and maps are known from experience to contain errors. Original water well records will be utilized during Phase 4A to check for these potential errors. As a consequence, the relative rankings of the sites as outlined in this report could change based on more detailed investigations.

Second, airphoto interpretation techniques, with limited field verification were utilized to define boundaries for some terrain features. As an example, where engineered flood plain mapping is available from the conservation authorities, the airphoto interpretation was checked against this more accurate mapping. However, only a small portion of the candidate areas has been mapped in detail. More detailed assessments will be undertaken during Phase 4 studies on the eight candidate sites.

Third, the conclusions contained in this report on exclusionary factors are based on

i) the present understanding of the facility characteristics and emissions that may come from these facilities as described in Section 1.5, and

ii) the OWMC site selection principles outlined in Section 1.3.

Consequently, the conclusions contained in this report should not be universally applied to other waste management projects without a thorough review and understanding of the

implications associated with the provisions outlined above.

The methodology employed in this study accommodates the forementioned limitations through the progressive refinement of the data base at each stage in the site selection processes.

2.0 IDENTIFICATION OF SITE AREAS

2.1 BACKGROUND

Phase 2 studies carried out by GLAL for OWMC in 1982 identified Zone 1 and 2 lands within the Golden Horseshoe Candidate Region as preferred locations for facility siting. Phase 3 Interim studies carried out in early 1983 further narrowed the search within the Zone 1 and 2 lands. The hydrogeology studies carried out as part of Phase 3A at that time divided the Zone 1 and 2 lands into four Regional Categories. Only Category 1 and 2 lands were considered to be underlain by geologic and hydrogeologic conditions acceptable for facility siting purposes and were carried forward into the Phase 3B site selection process.

In particular Category 1A, 1B and 2A lands only were considered acceptable for siting landfill and integrated facilities. All Category 1 and 2 lands were considered suitable for the physical/chemical treatment and/or incinerator facilities. The reader is referred to the OWMC Interim Phase 3 Report May 1983 and the GLAL report titled Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region, 1984 for more details.

On the basis of the hydrogeologic analysis and the other multidisciplinary factors considered, 20 candidate areas were identified within the Zone 1 and 2 lands in the Golden Horseshoe.

Site areas were identified within the 20 candidate areas by a process known as constraint mapping. The physical

resource component of the constraint mapping process was directed at identifying those smaller portions of the candidate areas which are not likely to provide the high degree of natural containment of contaminants desired and thus can be excluded from further consideration at this time.

During constraint mapping emphasis was placed on identifying readily mappable physical resource features or conditions which may influence facility development. These physical resource features and conditions were used as contraint mapping "factors".

Physical resource features include geology, terrain, hydrogeology and surface drainage considerations. Many of these considerations represent additional information to the previous geologic or hydrogeologic assessments used as a basis for the Interim Phase 3 report. The constraint mapping studies, therefore, augment and refine the previous geologic and hydrogeologic data base within the Category 1 and 2 lands only. In total, ten different types of physical resource factors have been identified and their significance for facility siting is discussed.

2.2 FACTOR IDENTIFICATION AND METHODOLOGY

In contrast to some of the other study teams, the physical resource study team did not identify physical resource factors for constraint mapping purposes at the outset of the investigations. Rather, the 20 candidate areas were initially studied to identify the physical resource features present. Once the major features were identified, their significance to facility siting was assessed based on the site selection principles, goals and objectives previously discussed. For consistency

purposes the physical resource features are referred to as "factors" for constraint mapping.

The physical resource factor ranking was achieved through discussions with OWMC staff, other consultants and input from the public consultation program. A detailed discussion of the input from public consultation is contained in OWMC Phase 3 Facilities Development Process report, March 1984, and in the 1984 Site Selection Technical Report prepared by M.M. Dillon Limited. A summary of the public consultation program contributions on physical resource factor ranking is contained in Section 2.4 of this report.

2.2.1 DATA COLLECTION

This study assembles information from a variety of sources. Although it primarily represents an interpretation of aerial photographs, where applicable, the study also used information from existing literature.

Essentially, three general sources of information were used in this study. These included:

1) a "desk top" analysis of aerial photographs and existing literature;

2) interviews with government personnel, and

3) reconnaissance field work.

The types of literature that were consulted included:

- published government geology reports and maps, and, reports and maps of agricultural soil surveys;

- hazard land maps prepared by the Ontario Ministry of Natural Resources;
- wetland maps prepared by the Canada Centre for Inland Waters (CCIW);
- flood plain mapping from conservation authority offices;
- Ontario Ministry of Natural Resources 'District Land Use Guidelines' documents, and
- official plans.

References used are listed under "References and Bibliography". Applicable information from these literature sources, was cross-referenced with an interpretation of aerial photographs. Examples of cross-referencing involved geologic features such as drumlins and moraines and drainage conditions such as wetland areas and flood plains. The airphotos that were used in this study were obtained from the National Airphoto Library in Ottawa. These photos were taken in 1980 and are at an approximate scale of 1:50,000.

This analysis enabled refinements to be made to existing information, as well as providing further details where information sources are incomplete. Examples of this included the identification of potential moraine features in Halton-Peel Regions that formerly had not been noted in the literature, and the delineation of flood plains.

During the course of the study, interviews were held with local conservation authority personnel regarding flood plain

mapping and Ministry of Natural Resources personnel regarding hazard lands.

Once the office studies were complete, reconnaissance field checking along existing roads was carried out. This provided the physical resource study team with a general impression of conditions on the ground as related to the results of the office studies.

The results of the study were plotted on a reproduction of the 1:50,000 scale National Topographic Series map base. Five physical resource maps were prepared and are presented in the Technical Data Map Portfolio.

A series of overlays were prepared of the physical resource factors at a 1:50,000 scale. These overlays were used by OWMC staff and the consulting team in the identification of site areas.

2.3 PHYSICAL RESOURCE FACTORS - CONSTRAINT MAPPING

Ten physical resource features were identified in the candidate areas. A detailed description of each feature and its significance to facility siting is provided in the following discussions.

2.3.1 TILL AND GLACIOLACUSTRINE CLAY PLAIN

The geographic area covered by this factor represents the majority of the lands within the present candidate areas. By comparison, the area of all other physical resource factors taken together is smaller in size.

The geology and hydrogeology of these areas has been fully documented in the Geologic and Hydrogeologic Inventory

of the Golden Horseshoe Candidate Region report (GLAL 1984). This report should be referred to for details on subsurface conditions with regard to placement of facilities. In general, most of this feature has uniform clay-silt sub-soils of varying thickness. Areas where these uniform conditions may only occur on a local scale have been identified in the western regions of the Niagara Peninsula and within Candidate Areas 4, 14 and 20 south and east of Brampton.

Although there is some variability in the topography of these areas, the surface expression of the land can generally be described as gently rolling or undulating to level. The more rolling to undulating areas occur in the Halton-Peel candidate areas and in the western portions of the Niagara Peninsula region including Candidate Areas 6, 7, 16 and 17. The local variability of relief in Niagara can be attributed to the undulating nature of the underlying glacial till or to an erosional type of landscape dissected by many small intermittent drainage courses. The relief of these areas may create local slope conditions of 5% to 10%. These areas are generally well drained.

In general, within the candidate areas of approximately the eastern two-thirds of the Niagara Peninsula, the topography is gently rolling to almost flat. It is partly because of this condition, that large portions of this area are poorly drained. Areas, where this condition (poor surface drainage) predominates, have been separately identified and are described in a later section of this report. Small and isolated surface depressions and drainage swales may occur randomly within this general eastern Niagara area of the till and glaciolacustrine clay plain.

Local areas of steep slopes do occur and these are mainly associated with the valley walls of river systems that are deeply incised into the overburden soils. Many of the streams in Halton and Peel regions share this condition as well as portions of the stream and river valleys in Niagara.

The fine textured soils present in this terrain feature will restrict the movement of contaminants downwards and thus provide protection of buried ground water resources beneath the till and lacustrine clay plain. The best protection of underlying water resources is afforded by the thickest and most uniform silt/clay soils. Human health risks are minimized in such areas. The uniformity of subsurface conditions and thickness aspects within this terrain feature are depicted on the Hydrogeology map contained in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report (GLAL 1984). Lateral movement of ground water contaminants towards surface water courses is also somewhat restricted in fine-textured soils. The possibility of impacts on the surface water environment is considered to be low.

2.3.2 DRUMLIN (HALTON)

Only a few of these oval-shaped features have been identified in the Halton-Peel Regions. Of these, only one appears to occur within the candidate areas.

The drumlins in this area consist of the same fine-grained silty to clayey Halton Till that occurs within the adjacent candidate areas. From a facilities siting point of view this terrain feature affords similar protection of ground water resources and thus humar. health risks are minimized. Similarly the possibility of impacts on the surface water environment is considered low.

2.3.3 DRUMLIN (NIAGARA)

Drumlins are oval-shaped hills, which are elongated in the direction of glacial ice movement. The drumlins of the Niagara area were deposited as an integral part of their respective glacial till unit, the sandy silt Wentworth Till. Drumlins of this till commonly contain granular zones within the sandy till matrix.

These features have been addressed previously in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region (GLAL 1984). They occur in Candidate Areas 7, 8 and 17. As a result of the present study, some additional features, other than those noted in the literature have been identified from the airphotos as potential drumlins.

The significance of these drumlins in siting facilities is that the sandy till and granular materials of which they are composed, may be sufficiently permeable to allow rapid migration and dispersal of contaminants through the granular. This could not only adversely affect underlying ground water resources, and thus human health, but also surface water bodies where hydraulic connection occurs between the till and local streams, for example. Thus the possibility of impacts on the surface water environment is also considered high.

2.3.4 DRUMLIN FIELD

The drumlins in the Niagara area occur in groups and occupy part of what is known as the Caledonia Drumlin Field. This drumlin field, as shown in Maps G-PR3 and G-PR4 in the Technical Data Map Portfolio varies in areal extent to that shown in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region (GLAL 1984). The primary reason for the refinements shown in this report and accompanying maps is that

the present study identified potential drumlins in addition to those indicated in the literature that was relied on for the geologic inventory work. The drumlins that are exposed at ground surface within the drumlin field area protrude through silt and clay sequences of glacial and glaciolacustrine origin. Mapping by the Ontario Geologic Survey suggests that the sandy Wentworth Till may generally underlie the silts and clays of this area to variable depths and that drumlins composed of this sandy till material may be buried beneath the surface between the known drumlin exposures. In other words, the surface of the Wentworth Till may undulate in a pattern that does not necessarily reflect the surface expression of the land. Figure 3 illustrates this relationship.

FIGURE 3: SCHEMATIC CROSS-SECTION OF CLAY-SILT/WENTWORTH TILL RELATIONSHIP

Although the clays of this area may reach depths of 20 m (Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report, GLAL 1984), it is difficult to predict the upper elevation of the Wentworth Till relative to the ground

surface, as well as the possible locations of buried drumlin occurrences. The lines drawn to delineate the extent of the drumlin fields are subjective and are approximate at best. The drumlin field is transitional into consistently deeper areas of clay to the east and north.

Because of the uncertainties associated with the possible presence of buried drumlins and shallow depths to the sandy Wentworth Till, precautions must be taken if facilities are sited on this terrain feature. Detailed surface mapping and evaluation of subsurface conditions using drilling techniques would be needed to assess this condition and the general disposition of the buried Wentworth Till in relation to locating a hydrogeologically safe and predictable site. For these reasons the risks to human health, as a result of ground water contamination could vary from low to high depending on site specific conditions. Similarly, the possibility of impacts on the surface water environment are considered to be low to high.

2.3.5 MORAINE

These features occur in relatively few portions of the candidate areas. Three are potentially involved -- two occurring in Halton-Peel and one in Niagara. All three can be recognized by their surface topographic expression.

The moraine in Niagara, referred to as the Fort Erie Moraine, occurs in the western portion of Candidate Area 18 and is identified in the literature (Feenstra 1981a) and discussed in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report (GLAL 1984). The moraines in Halton-Peel are not identified in existing literature sources. One occurs in the western extremities of Candidate Area 5 and the other in Candidate Areas 4 and 14.

The general concern with moraines is that they may contain inclusions and/or pockets of granular materials that could provide ready pathways for the migration of contaminants in the ground water flow system.

As noted in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report (GLAL 1984), several fragments of the Fort Erie Moraine occur in the Niagara area. The present terrain survey has confirmed the mappable ridges in the Binbrook area. However, neither the present study or the above mentioned study has been able to substantiate the "inferred" portion of the Fort Erie Moraine, which Feenstra (1981a) suggests between Binbrook and Fenwick. The Vinemount Moraine also referenced in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report (GLAL 1984) likewise is not discernible by surface phenomenon within the candidate areas.

Although the moraines in Halton-Peel have not been thoroughly investigated, there are some early signs to indicate granular materials may be locally present, particulary in the small morainal feature in Candidate Area 5. This potential moraine is ridge shaped, stands up to about eight metres above the surrounding terrain and appears to be about 20 to 60 metres wide at its base. Granular materials have been noted in at least one surface exposure. The surrounding areas are composed of granular materials as well, hence good hydraulic connection may exist in a lateral direction away from the moraine. This situation could potentially allow contaminants to move with relative ease in the ground water flow system.

The low ridge-shaped landform that traverses portions of Candidate Areas 4 and 14 is similar in topographic expression

to the Trafalgar Moraine and may represent an easterly extension of this feature. Surface granular materials are not known to exist in this feature although the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report, (GLAL 1984) suggests buried granular materials may exist particularly toward the south of this area.

In all of these moraines sub-surface exploration is needed to properly define the geologic and hydrogeologic conditions (i.e. presence or absence of granular materials). There may very well be areas containing uniform conditions of fine textured glacial till. Hence these moraines should be considered as a condition of concern rather than an absolute constraint to siting. Because of the uncertainties associated with the presence or absence of granular materials within the moraines, risks to human health resulting from potential ground water contamination are considered to vary from a low to a high constraint. Similarly, the possibility of impacts on the surface water environment are considered to be low to high. Relative to other features, there is a lower likelihood of sites proving acceptable after detailed site specific analysis.

2.3.6 SURFACE GRANULAR SOIL

Potentially significant deposits of granular soils have been mapped in the eastern portion of Candidate Area 5.

These deposits appear to form a continuous blanket of material overlying glacial till to depths that may exceed one metre. They abut Sixteen Mile Creek in the area of the community of Drumquin and extend easterly to surround a small moraine feature. The granular materials primarily consist of sand with occasional gravel phases and were probably deposited by fluvial and lacustrine processes during the Peel Ponding. The main use

of these areas is presently agricultural, specializing in nursery, vegetable and fruit crops.

The granular materials of this area are relatively more permeable than the surrounding and underlying clay-silt tills. Some portions of the deposit may be deep enough to be used as a source of water for shallow large diameter wells. These areas may also function as an important ground water recharge source which contribures to the baseflow of local streams.

The significance of locating facilities in these areas is that the granular materials could potentially provide ready pathways for movement of contaminants in the ground water flow system. This may not only adversely affect ground water but also adjoining surface water resources. As such there is a high risk to human health and the possibility of impacting the local surface water environment is high.

Throughout the remainder of the candidate areas, the soils have been mapped as silts and clays of lacustrine or glacial origin. However, local small areas of shallow, sandy phases of the lacustrine deposits may occur. These usually form as a result of erosional activity and could be expected to mainly occur in areas of locally higher relief. They are not felt to be a concern for siting facilities at this stage but should be assessed at a more site specific phase of the program.

2.3.7 POOR SURFACE DRAINAGE

Poor surface drainage occurs on portions of the flat lacustrine clay plains of the Niagara Peninsula. The largest continuous area of poor drainage conditions occurs west of the Town of Welland and north of the Welland River in Candidate Area 18.

Smaller areas are indicated south of Niagara Falls in Candidate Areas 13 and 14.

Poor drainage conditions are characterized by the occurrence of small shallow depressions or swales which are often water filled (wetlands) or have a water table very close to surface. Most of these wetland areas have not been farmed and are often wooded. Shallow organic deposits may occur in these depressions.

Although surface drainage networks are poorly developed in relation to these wetland features, many of the wetlands may be connected to local streams and contribute to their flow for at least part of the year.

In general, the wetland organic filled depressions occupy only a small portion of the total poor surface drainage area. The intensity or density of the wetland condition will vary from one area to another. Estimates range from about 5% to 25% of the total poor surface drainage area. Many of the higher percentages appear to occur east of Welland and south of Niagara Falls. The size of individual wetlands within this terrain feature is estimated to often be less than 1 or 2 ha. Because of the small size of the individual wetlands, they cannot be meaningfully or accurately mapped at the 1:50,000 scale.

The presence of this condition should generally not inhibit the selection of sites at this phase of the program. If some of these wetland conditions do occur within a site area, it may simply be a matter of treating them with drainage or engineering works, which might include excavation of soft organic soils and filling with suitable earth materials. Other solutions might simply involve positioning facilities such that

the wetlands are completely avoided.

The implications for environmental impacts or risks to human health must be considered when siting in the vicinity of the wetland depressions. In such cases, consideration may have to be given to using remedial measures to guard against potential contaminants gaining access to the wetlands and adversely affecting surface water within the wetland or possibly to connecting stream courses. When individual sites are being considered this condition will have to be precisely defined at the appropriate scale of mapping.

We consider this feature to represent a low to moderate risk to human health and the possibility of impacts on the surface water environment are considered low to moderate.

2.3.8 WETLAND

Wetland areas mainly occur in the Niagara Peninsula and are associated with conditions of very poor drainage on the clay plain. In most cases these areas occur as discrete isolated units that are surrounded by well to imperfectly drained farm land. Only a few small local wetlands are noted in the Halton-Peel Regions. The greatest concentration of wetlands appear to occur in the central and eastern portions of Candidate Areas 8 and 18.

Wetlands occur in depressional areas and commonly have high water table and/or standing water conditions, which prevail for much of the year. In general these areas are wooded or covered with shrub vegetation and are not farmed. Organic soils can be associated with these areas and depths of up to a metre or more locally can be expected.

There are several factors to take into account should these areas be considered as facilities sites. Remedial engineering might include draining, excavation and removal of soft organic materials, and replacing with fill of suitable construction quality. Flood proofing may also be required. Many of these organic wetland areas, that discharge to streams, may serve a natural function of controlling flooding during high run-off periods and providing stream augmentation during dry periods. By draining and filling these areas, this role would be lost. From a biological perspective, these areas may support important vegetation, aquatic and wildlife forms, which could be adversely affected. If facilities sites are located adjacent to these areas, precautions should be taken to guard against possible contamination of surface waters that may occur within their boundaries. In this instance, livestock and wildlife watering areas could be adversely affected. Consequently, reliance on engineering to contain contaminants would be required and these features do not provide a second level of defense. As such the risk to human health and potential impacts on the environment are considered high.

Although the study has probably identified the majority of these areas, small units less than about 5 ha may not be shown since they would be too small to map at the 1:50,000 scale. In general the boundaries of organic soil units can be considered as fairly accurate, although they may be considered approximate in heavily treed areas. It is in these areas, where in some cases, there are indications that the organic soil areas may be discontinuously mixed with well to imperfectly drained mineral soils. This condition is too complex to show at the 1:50,000 scale, but can be refined at the appropriate scale, if necessary, during more detailed site specific studies.

2.3.9 FLOOD PLAIN

The major river valley systems that are prone to flooding have been mapped. In the Niagara Peninsula area these include the Grand River, Welland River, Twenty Mile Creek, Lyons Creek, Usshers Creek, Black and Beaver Creeks, as well as some of the tributaries of these streams. In the candidate areas of Halton-Peel, the major flood plain lands are associated with the valleys of Bronte Creek, Sixteen Mile Creek and Fletcher's Creek.

These areas have primarily been identified by stereoscopic interpretation of airphotos, and they provide a general indication of areas that are susceptible to flooding. Where detailed flood plain mapping, which is determined by engineering methods, is available, checks were made to ensure that the results of the two techniques were in general agreement. The detailed mapping, where available has been utilized in this study.

Flood plains are identified on the airphotos as generally flat-lying bottomland that is usually close to the level of adjacent stream courses. Their boundaries are often defined by distinct topographic differences, which demark the edge of the valley systems and are clearly seen on the airphotos. However, in some instances, where very flat areas are involved, the distinction is not as clear and the outline of these areas is somewhat subjective. Such is the case on some of the streams in Candidate Areas 13 and 19, and indicators such as soil drainage and crop patterns are used to make judgements. However, some of the streams in these candidate areas have engineered flood lines that are based on field measurements and detailed hydrology studies. These have been used and plotted on the terrain map where available.

In general, only the larger flood plains, compatible with the detail that can be reasonably shown at the 1:50,000 scale, which includes those that have engineered flood lines, are shown at this stage of the study. When individual sites are examined more detail may be required commensurate with the scale that is used at that time. This might include use of the engineered flood lines, where presently available, or in some instances where this is not available, detailed original work including airphoto interpretation and/or engineered flood plain mapping may be required.

Detailed engineered flood plain mapping has not been completed for most of the creeks and rivers in the study area. This form of mapping is in progress on some streams and preliminary results may soon be available. Such is the case on the middle and lower portions of the Welland River, Forks Creek, Beaver and Black Creeks north of Fort Erie, Bronte Creek, Beaver and Black Creeks north of Fort Erie, Bronte Creek and all branches of Sixteen Mile Creek in Halton.

Other characteristics of flood plains include soft alluvial soils that may have poor foundation conditions, wetland organic soil conditions and water tables tha may be at or close to the surface. Aside from these concerns, the major factor to consider here is that sites located in these settings would be subject to inundation and damage caused by flooding unless otherwise protected.

Another potential concern is that if contaminants escape into these areas, they could experience rapid dispersion in surface waters, which in turn could result in severe impacts to aquatic life and potable water supplies. These risks to

human health and the possibility of impacting the surface water environment are high.

2.3.10 STREAM COURSES

These features represent major tributaries of the main creeks and rivers. Generally they may be classified as second order streams. Only those having valleys that are clearly defined with discernible potential flood zones at the 1:50,000 scale of mapping have been noted. Differences in topography, as related to the bounds of the stream valleys, is the main indicator used to delineate these features. Some of these streams may have flood plains that are as much as 30 m or more wide.

There are many smaller stream channels or swales that are also evident on the airphotos and to a large extent represent the micro drainage network. These do not have clearly defined flood zones at the 1:50,000 scale, and as such are not shown at this time. These smaller drainage channels in some form, will probably affect any given property. Consequently they should be dealt with on a site-specific basis at the appropriate map scale.

The same concerns for siting facilities exist here as described for the flood plains. These are, 1) the potential for rapid dispersion of contaminants should they be allowed to enter these surface water bodies, (this could lead to adverse effects on potable water supplies and aquatic life), and 2) the potential for inundation and damage caused to structures as a result of flooding. As such potential risk to human health and major impacts on the environment are considered to be high.

Although detailed engineered flood plain mapping has been initiated on a few of these streams, none have been completed

to date. Hence, flood plain mapping regulations may only apply on an individual site specific basis. Nonetheless, the concerns as stated should be fully considered in siting any of the facilities. In some instances, it may be possible to relocate small streams and/or provide engineered protective works for the facility. Detailed airphoto interpretation and/or engineered flood plain mapping may be required to properly define the extent of these areas at the site level of detail.

2.4 FACTOR RANKING AND APPLICATION

Ten physical resource factors were identified and mapped during constraint mapping. Individual factor sheets are provided in Appendix A and the geographic distribution of these factors is shown in maps G-PR1 to G-PR4 of the Technical Data Map Portfolio.

The significance of these ten factors with respect to facility siting is summarized in Table 3.

Five factors are associated with major constraints necessitating reliance on engineering to contain potential contaminants and thus are not likely to provide the desired second level of protection. These are:

- surface granular soil,
- stream course,
- flood plain,
- wetland,
- drumlin (Niagara).

Major potential risks to human health and potential impacts on the environment may result if facilities are developed on lands containing these features. These negative attributes

TABLE 3: SUMMARY OF PHYSICAL RESOURCE FACTORS AND THEIR SIGNIFICANCE TO FACILITY SITING.

FACTOR \ SIGNIFICANCE	RISK TO HUMAN HEALTH	IMPACT ON ENVIRONMENT	COMMENTS
Till and lacustrine clay plain	L	L	- provides natural containment
Drumlin (Halton)	L	L	- provides natural containment
Poor surface drainage	L-M	L-M	- some surface drainage and environmental concerns
Moraine	L-H	L-H	- difficult to confirm suitability
Drumlin field	L-H	L-H	- difficult to confirm suitability
Drumlin (Niagara)	H	H	- major potential adverse effects, no second level of protection
Wetland	H	H	- major potential adverse effects, no second level of protection
Surface granular soil	H	H	- major potential adverse effects, no second level of protection
Flood plain	H	H	- major potential adverse effects, no second level of protection
Stream course	H	H	- major potential adverse effects, no second level of protection

KEY

L - likelihood of risk to human health or impact on environment is low

M - likelihood of risk to human health or impact on environment is moderate

H - likelihood of risk to human health or impact on environment is high

are contrary to the fundamental site selection principles and goals discussed in Sections 1.3 and 1.4.

Two factors -- drumlin field and moraine, may contain variable subsurface conditions. While it is possible that portions of these lands may contain uniform, fine-grained soils, the likelihood of finding such areas, even after detailed site drilling is considered low relative to other features. As such, consistent with the "Likelihood of Suitability" principle, less priority was given to these two features and they have been considered as exclusionary at this time.

The preferences expressed at the workshops (OWMC 1984) were in general agreement to the factor treatment discussed above. The exceptions were for placement of the incinerator facility on surface granular soil, drumlin (Niagara), drumlin field and moraine. Opinion was split on this consideration. However, the physical resource study team concluded that these features did not provide a second level of protection to human health and the environment. Having regard for the fact that untreated organic wastes would be handled at this facility, it is reasonable to conclude that this second level of protection was required and the factor was treated as exclusionary.

Three physical resource factors have been identified as non-exclusionary. These are:

i) till and lacustrine clay plain,
ii) drumlin (Halton),
iii) poor surface drainage.

The first two factors have uniform predictable characteristics. The natural attributes of these factors should naturally restrict the movement of contaminants. Strict reliance

on engineering to minimize risk to human health and impact on the environment would not likely be required.

The third factor, poor surface drainage, may require some mitigative measures. These could be as simple as facility placement to avoid the feature, to modifications of surface drainage conditions during site development. No major adverse effects were identified. Inasmuch as this feature is associated with deep, uniform clay textured soils, retaining these areas for further analysis contributed to diversity of choice.

Workshop preferences were in agreement with GLAL treatment of the till and lacustrine clay plain. A distinction between the Halton drumlins and Niagara drumlins was not made and this led to a preference for treating Halton drumlins as exclusionary. Workshop participants preferred to treat poor surface drainage as an exclusionary factor. Inasmuch as details of the concern could not accurately be defined at the 1:50,000 scale, the physical resources team decided to leave the poor surface drainage areas in and to carry out more detailed studies at the site specific stage. This contributed to diversity of choice, provided that mitigative measures are potentially minor in nature. There is a high likelihood that, with mitigative measures, the surface drainage features could prove acceptable for siting after more detailed studies have been undertaken. For these reasons it was not excluded.

2.5 OTHER CONSTRAINT MAPPING CONSIDERATIONS

After an initial application of the preliminary listing of exclusionary factors a number of site areas were identified. At this stage of the constraint mapping exercise, these site areas were considered preliminary conclusions inasmuch as

diversity of choice and trade-off issues were not yet considered as a siting issue.

Public involvement in the factor ranking process and identification of siting issues influenced the factor ranking for some factor groupings. As indicated in the previous section there was general agreement with regards to the physical resource factor ranking. A review of the factor rankings was undertaken to determine if dropping some of the exclusionary factors or a subdividing within a factor was possible. It was concluded that this was not possible, particularly if the fundamental site selection principles and goals and objectives were to be met. As such no changes to the physical resource factor ranking occurred.

Issues identified during the workshops that influenced the site selection process from a physical resource perspective are:

i) retain siting opportunities which minimize transportation haulage and/or maximize the depth and consistency of silt clay soils. Although the majority of the workshop attendees preferred deeper clay soils over transportation haulage distance, there were some divided opinions. As such, it was decided to retain siting opportunities which favoured both sides of the trade-off.

ii) Maximize opportunities for siting on deep consistent clay soils. The workshop participants agreed with OWMC's position that if necessary, as a second choice,

preference should be given to sites with deep clay soils over agricultural capability/productivity factors.

To reflect public input, address diversity of choice and address the trade-off issues, the OWMC staff and consulting team decided to consider relaxing the agricultural exclusionary factors (except for specialty crops) for areas that were highly accessible or highly accessible with deep clay soils.

After a review of the accessibility issue by the Dillon transportation consultant, it was identified that Candidate Areas 3 and 5, north of Lake Ontario were the only instances of the deepest clay soils in the most accessible of the Candidate Areas (Category 1A levels). Areas of deep clay soils (Category 1A) south of Lake Ontario are present in the eastern portion of Candidate Area 18. Transportation access to this area has been identified as being only average to below average. However the 1B lands west of this 1A area (also Candidate Area 18) stretching from Wellandport to Binbrook were considered to have somewhat better access than the 1A portion in the Niagara Peninsula.

In order to assess the transportation issue in more detail, prior to dropping agricultural factors as exclusionary south of Lake Ontario, a more detailed assessment of the transportation corridors into the western end of Candidate Area 18 was undertaken.

The physical resource study team assessed the designated access routes from a potential effects on human health and the environment perspective, resulting from accidental spills during transit. Route numbers, destinations, and route segments are

contained in the M. M. Dillon Limited Phase 3B Site Selection Report, 1984 and should be referred to for clarification of the tables contained in this section. Sensitive lands that could allow subsurface migration of contaminants into well water supplies or into surface water were identified.

Sensitive lands are identified as those lands underlain by:

- bedrock at or near surface,
- granular at or near surface,
- flood plain deposits (generally variable textures),
- man-made fill (excavation material from the Welland Canal - variable texture).

The physical resource study team recognizes that an emergency response spill clean-up team will be established as part of the facility operations. As such any spills that do occur will be attended to immediately. For this reason, the access route physical resource factor is not considered to be a major consideration in overall access route ranking or site ranking.

Existing literature was used to assess sensitive lands. No field checks were undertaken. The results of the analysis are contained in Table 4 and are simply expressed as metres of sensitive lands traversed by a route.

For the purposes of analysis, the routes with the least amount of sensitive land are considered to have low constraints and routes with the maximum amount of sensitive lan are considered to be proportionately more constrained.

The results of the application of this and other factors are discussed in the Dillon Site Selection Technical Report,

TABLE 4: CENTRAL AREA ROUTE ASSESSMENT PHYSICAL RESOURCE CONSIDERATION

DESTINATION (NO.)	ROUTE NO.	SEGMENT	SENSITIVE LAND (M)	TOTAL FOR ROUTE (M)
Binbrook	1	a	1860	
		b	--	1860
Caistor Centre	1	a	1860	
		c	--	
		d	--	1860
Windslow	1	e	2275	
		g	--	
		m	900	
		n	400	
		p	200	
		q		3775
Vaughan	2	j	550	
		k	1640	
		l	375	
		n	400	
		p	200	
		r	--	3165
Bismark	4	x	2730	
		u	200	2930
	5	y	4569	
		z	--	4569

Special Note: See Map 3, Volume 4 of M.M. Dillon Limited Map Portfolio.

1984. In summary it was decided that the alternative route assessment did not identify any clear preferences that could substantiate compromising the agricultural criteria.

2.6 CONCLUSIONS AND RECOMMENDATIONS

For the purposes of the combined constraint mapping exercise, three physical resource factors are considered nonexclusionary for facility siting purposes. These are:

i) till and lacustrine clay plain,

ii) drumlin (Halton),

iii) poor surface drainage.

The distribution of these factors in the Golden Horseshoe candidate areas is depicted in maps G-PR1 to G-PR4 of the Technical Data Map Portfolio. These maps should be used in conjunction with the Hydrogeology Map contained in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report (GLAL 1984) and the OWMC Interim Phase 3 Report, May, 1983 to identify potentially acceptable site areas for locating the various facilities. Reference is made to Section 2.1 of this report for a brief discussion of the significant hydrogeologic results from the two above mentioned reports.

In summary,

1) *landfill site areas, on the basis of the physical resource factors, can be potentially sited on Category 1A, 1B and 2A lands (see Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report, GLAL 1984) that have not been excluded as a result of the physical resource*

constraint mapping studies described in this section of the report.

2) *The physical chemical treatment plant and/or the incinerator can potentially be sited on all Category 1 and 2 lands (see Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region report, GLAL 1984) that have not been excluded as a result of the physical resource constraint mapping studies described in this section of the report.*

3.0 IDENTIFICATION OF POTENTIAL SITES - SITE SCREENING

3.1 BACKGROUND

A total of 65 landfill/integrated site areas and 87 physical/chemical treatment and incinerator site areas were identified as a result of the constraint mapping stage of the selection process. The second stage in the process, known as "site screening" reduced the site areas in number and size to potential sites using multidisciplinary screening factors.

The site screening process took place in two steps with site areas being dropped from further consideration or reduced in size at each step.

3.1.1 STEP 1

During Step 1 existing constraint maps, including the physical resources constraint maps, and various planning considerations were used to adjust site area boundaries. This work was undertaken by the site selection consulting team at a scale of 1:50,000. Several site areas were set aside at this point because the boundary adjustments resulted in site areas that were either too small or unsuitably shaped to accommodate the size of facility required. In some instances however, it was necessary to include a specific constraint feature, such as a flood plain, within the site area boundary because of property acquisition limits. This was done with the understanding that the constrained lands would not be used for facility siting but rather may form part of the technical buffer to be established around the facility.

Step 1 resulted in the reduction of site areas to a shorter list of 38 landfill/integrated site areas and 52 physical chemical treatment and incinerator site areas.

3.1.2 STEP 2

Table 5 lists the site areas that were studied in greater detail during Step 2. All work was undertaken at a scale of 1:10,000. The size of the site areas is larger than that eventually required for the facilities. This permits the modification of boundaries as the Phase 3B studies evolve. The text which follows describes the methodology and results of the analysis conducted during Step 2.

3.2 FACTOR IDENTIFICATION AND METHODOLOGY

3.2.1 FACTOR IDENTIFICATION

Three physical resources factors -- "Natural Containment Potential", "Aquifer" and "Surface Drainage" were identified, defined and applied by the physical resources study team during the site screening process. These factors were selected because they:

- are compatible with the site selection, goals, and objectives, and facility characteristics assumptions;
- reflect the level of detail that can be accommodated using previously collected information and any additional information that may be collected during brief roadside visits to the site areas;

TABLE 5 SITE AREAS SCREENED

Landfill/Integrated Sites Areas *

LF-1A1	LF-2W	LF-1C	LF-1E
LF-2A1	LF-3W	LF-2C	LF-2E
LF-1N	LF-4W	LF-3C	LF-3E
LF-2N	LF-5W	LF-8C	LF-4E
LF-3N	LF-7W	LF-9C	LF-6E
LF-4N	LF-10W	LF-12C	LF-7E
	LF-11W	LF-13C	LF-8E
	LF-13W	LF-15C	LF-9E
	LF-14W	LF-18C	LF-10E
		LF-24C	LF-12E
		LF-25C	
		LF-29C	
		LF-30C	

Physical/Chemical Treatment and Incinerator Site Areas *

PI-1A1	PI-2W	PI-1C	PI-1E	PI-14E
PI-2A1		PI-2C	PI-2E	PI-15E
PI-3A1		PI-11C	PI-3E	PI-16E
PI-1N		PI-15C	PI-4E	PI-17E
PI-2N		PI-19C	PI-5E	PI-18E
PI-3N		PI-21C	PI-6E	PI-19E
PI-4N		PI-22C	PI-7E	PI-20E
PI-5N		PI-25C	PI-8E	PI-21E
PI-6N		PI-26C	PI-9E	PI-26E
PI-10N			PI-10E	PI-27E
PI-11N			PI-11E	PI-30E
PI-12N			PI-12E	PI-31E
PI-13N			PI-13E	PI-34E
PI-14N				PI-37E
PI-15N				

Notes: * Site Identification System
(LF) - refers to integrated/landfill site area
(PI) - refers to physical/chemical treatment plant and/or incinerator site area
(#) - sequential number assigned to site area
(Letter) - refers to site's geographic location relative to the western end of Lake Ontario (A1 - refers to Toronto (A1) area)

The locations of these site areas are presented in Figures 14 and 15 of the OWMC Phase 3 Report, March 1984.

- could be applied in a manner which would facilitate the differentiation and ranking of site areas and the identification of potential facility development constraints (process is described in Section 3.4).

3.2.1.1 Site selection goals and objectives, and facility characteristics assumptions

As discussed in Section 1.4 in order to minimize risk to human health, minimize environmental impact and minimize financial cost to OWMC, it is necessary to assess:

- the "pathways" through which contaminants may move (subsurface geology);
- the potential "receptor" which may be affected (aquifers, surface water);
- the likelihood of implementing major and potentially costly site improvements (surface drainage considerations).

The natural containment factor encompasses those physical resource considerations which influence contaminant movement through the subsurface "pathway". The sites physical setting should provide a second level of protection by naturally containing contaminants. This contributes to the protection of human health and the environment. For planning purposes, about 20 m of fine-textured soils are preferred for landfill and integrated facilities, while 10 m of such soils are preferred for physical/chemical treatment and incinerator facilities.

The aquifer factor provides preliminary information on the ground water resource receptors which may potentially be affected by subsurface contaminant movement. Ground water is used extensively in rural areas as a source of water supply.

The protection of this resource for current and projected future uses is fundamental to the site selection process.

The surface drainage factor combines those considerations related to the potential for contaminant movement from facilities due to the inundation or damage by flooding of the facilities as a result of locating on flood plains or adjacent to significant stream courses.

Stream courses act as both contaminant pathways and receptors. Flood plains may contain granular and organic soils and may act as contaminant pathways, or may require site improvements because of flooding and poor foundation characteristics. Wetlands may require site improvements such as remedial drainage due to standing water and/or excavation of soft organic material and filling to improve foundation characteristics.

Major stream courses, flood plains and large wetlands were identified and excluded during constraint mapping. Areas of poor surface drainage, although identified, were not excluded.

These poor drainage areas contain minor stream courses and small wetland areas.

The use of the larger 1:10,000 scale aerial photographs during this stage greatly facilitated the identification of these drainage features. It was therefore considered appropriate to introduce the surface drainage factor as a means of differentiating between the drainage features in terms of their anticipated constraint to facility development.

Detailed factor descriptions and discussions of their significance to facility development are presented in Section 3.3 and on the factor sheets in Appendix A.

3.2.1.2 Data base

The identification of factors was in part governed by the scale of analysis to be conducted during this stage in the site selection process. The analysis was largely restricted to the following data base.

- existing reports and information collected during previous phases and constraint mapping;
- aerial photographs at a scale of 1:10,000; and
- field observations made during brief roadside visits to the site areas during the winter and spring of 1983-1984.

3.3 FACTOR DESCRIPTIONS AND RATIONALE

The three factors and their significance to site development are described both in the factor sheets presented in Appendix A and in the following section.

3.3.1 NATURAL CONTAINMENT POTENTIAL

All facilities are to be located where the natural environment contains predictable, uniform, geologic materials that will retard contaminant migration. This necessitates identifying those hydrogeologic settings that are dominated primarily by thick, uniform, fine-textured soil material. Contaminant behaviour in such settings is reasonably predictable and the setting provides substantial lead time for implementing remedial measures in the event of an accidental spill or engineering failure. Emphasis is placed on establishing the uniformity, thickness and texture of the dominant geologic units underlying the site areas.

The hydrogeologic interpretation is based on the recognition that mappable (observed) geologic features are typically associated with assemblages of soil materials that have specific physical properties. These properties influence contaminant movement in the subsurface and are therefore indicative of the natural containment provided by the geologic materials underlying a particular site. The following indicators of hydrogeologic conditions were considered:

- Regional Categories (hydrogeologic condition and confining layer thickness established during Phase 3A);

- Geologic Material Texture (dominant geologic unit as based on landform/topography and material texture); and
- Geologic Predictability (stratigraphic complexities).

The significance of these indicators is discussed below.

Regional categories - A four category classification system was developed as part of the Interim Phase 3 (Phase 3A) studies in the course of delineating candidate areas in the Golden Horseshoe Candidate Region (GLAL 1984). Lands with similar geologic/hydrogeologic settings and hence contaminant containment potential were grouped into one of these categories.

Generally Category 1 lands are expected to be underlain by silt-clay soils with lateral and vertical textural uniformity, which range from 10 metres to over 30 metres in depth. Ground water and contaminant movement rates through the soil are predictably slow and the soil can be expected to have a high attenuation capability. These soils should provide natural containment of potential contaminants.

Category 2 lands are expected to be underlain by at least 10 metres of silt-clay soils exhibiting some variability. Thin, discontinuous granular lenses may be locally intermixed with the silt-clay. Category 2 lands may locally contain areas that are comparable to Category 1 lands.

Category 3 lands are characterized by a variety of geologic materials of various thicknesses. Granular materials are common allowing rapid movement of contaminants. The

hydrogeologic setting does not provide containment in a natural state.

Bedrock is generally within 10 metres of surface in the Category 4 lands.

Category 1 and 2 lands were further subdivided based on the expected thickness of silt-clay soils (confining layer thickness) into:

- Category 1A - greater than 30 m of silt-clay soil;
- Category 1B - between 20-30 m of silt-clay soil;
- Category 1C - between 10-20 m of silt-clay soil;
- Category 2A - between 20-30 m of silt-clay soil; and
- Category 2B - between 10-20 m of silt-clay soil.

The thickness of the confining layer as it relates to the ground water flow path can have a pronounced influence on the length of time necessary for a contaminant to move vertically through the soil layer. As the thickness of the confining layer increases, the travel time similarly increases. Soil units which are thick will provide relatively greater containment than units which are thin or of limited extent.

In fine-textured soils, where flow is a fraction of a metre per year, even a small thickness increase will translate into substantially greater containment.

As a general rule, only Category 1 and 2 lands were carried forward into Phase 3B from Phase 3A. Those site areas selected for landfill or integrated facilities are located on Category 1A, 1B and 2A lands only. Site areas

selected for physical/chemical treatment plant and/or incinerator site areas are located on undifferentiated Category 1 and 2 lands because of the thinner soil requirement (>10 m).

Geologic Material Texture - The "geologic material texture" indicator was developed to differentiate amongst the various geologic unit(s) based on their likelihood to retard (contain) contaminant movement.

The rate of ground water and contaminant movement is influenced by the pore spaces between grains (permeability). In granular materials, which are highly permeable, ground water and contaminant movement is potentially rapid. In fine-textured soils, which have low permeability, ground water and contaminant movement is slow. Fine-textured soils (silt and clay) effectively contain potential contaminants by retarding contaminant movement.

Three physical resource features, till and lacustrine clay plain, drumlin (Halton) and areas of poor surface drainage were carried forward from the constraint mapping stage. These features are dominated by two major geologic materials (units) -- Halton Till and lacustrine silt-clay. The poor surface drainage areas are a surficial consideration and will be dealt with in a subsequent section on surface drainage.

The Halton Till is the dominant geologic unit in the Toronto-Hamilton area. This unit is a silty to clay till with local interbedded granular lenses. Ground water movement through the till is very slow as a result of the low permeability. In general, the site areas located in the Toronto-Hamilton candidate areas are anticipated to be underlain by

fairly uniform silty to clay till soil. Although granular lenses may be present locally, these lenses are generally thin and of limited extent.

The Hamilton-Niagara Falls area is underlain by a glacial/lacustrine sequence consisting of three silt-clay units. Only minor variability has been noted in these units throughout the area. The three units together comprise the "clay" noted in the geologic log on water well records. Ground water and contaminant movement patterns are generally predictable in areas underlain by this stratigraphic sequence.

In the course of completing a review of the physical resources data base at the more detailed 1:10,000 scale, two additional geologic features with specific material assemblages were identified -- moraines and spoil (man-made fill).

The majority of moraines or moraine-like features were identified during constraint mapping and the "moraine" factor was treated as exclusionary because of the uncertainties associated with the presence (or absence) of granular material within the moraine. Moraines identified at the 1:10,000 scale represent a refinement of the 1:50,000 scale data base.

Spoil piles are common in the vicinity of the Welland Canal. Spoil consists principally of unconsolidated overburden and bedrock materials excavated from the canal during construction. Upon spoiling these materials are randomly distributed and will be differentially compacted by the various methods

used in excavation and stockpiling. Permeabilities are likely to vary substanitally resulting in unpredictable ground water and contaminant movement patterns.

Geologic Predictability: The "geologic predictability" indicator presents a refinement of the "Regional Category" and "Geologic Material Texture" indicators described previously. No additional information was collected in undertaking the analysis associated with this indicator.

Basically, in areas where the stratigraphy is variable and complex, ground water and contaminant movement patterns will likely be intricate and complicated. Ground water movement patterns are difficult to predict in such areas. Where the stratigraphy is dominated by uniformly textured soils which are continuous both laterally and vertically, ground water and contaminant movement patterns are predictable.

Regional Category 1 lands were identified as being underlain by uniform soils and as such are considered to represent a uniform and predictable hydrogeologic setting. Category 2 lands are locally associated with a greater degree of natural variability due to the presence of granular materials and therefore may locally represent a less uniform and predictable hydrogeologic setting.

As a result of the Phase 3A analysis, the candidate areas are located in areas underlain by Halton Till and lacustrine silt clay soil of uniform consistency. All site areas underlain by these geologic materials are therefore assumed to be located in a uniform and predictable hydrogeologic setting.

It should be noted that the area described as poor surface drainage in the constraint mapping section of this report is similarly underlain by these clay soils.

Because of the uncertainties associated with the moraine and spoil, these hydrogeologic settings are considered to possess variable geologic conditions. There is a high likelihood that sites located on these two features would prove unacceptable after a detailed drilling program is completed.

3.3.2 AQUIFER

Aquifers are geologic units or formations which are sufficiently porous and permeable to be capable of supplying ground water to wells at a usable rate. Ground water is used extensively in rural areas as a source of water supply for domestic and agricultural purposes. The "aquifer" factor is defined as those aquifers which provide the principal sources of ground water supply in a given area.

The protection of ground water quality for current and projected future uses is fundamental to the assessment of site suitability. Once ground water is contaminated, it is extremely difficult and expensive to institute an aquifer clean-up program and even then, the resource may be rendered unusable for tens if not hundreds of years.

Ground water is available for use in most areas of southern Ontario, although the value of the resource may vary significantly depending on the physical and chemical properties of the aquifer (water availability and quality), the uses of the resource and the availability of alternative water supplies.

The following aquifers (principal sources of ground water supplies), have been identified and are ranked below in order of their significance as sources of water supply.

- Granular deposits;
- Guelph/Amabel bedrock formations;
- Salina/Bass Island bedrock formations; and
- Queenston/Georgian Bay bedrock formations (granular materials at bedrock contact upper fractured portion of bedrock).

Granular deposits: Several of the site areas are underlain at depth by buried granular deposits. These deposits occur locally, both within the confining layer sequence and immediately over the bedrock. Many water supplies are developed in the granular. These wells are capable of yielding substantial quantities of good quality water.

Guelph/Amabel Formations: The Guelph-Lockport (Amabel) Formation is a highly productive limestone and dolostone aquifer. These limestones and dolostones are extensively fractured locally and secondary solutioning along these fractures is common. The Guelph-Lockport Formation has been locally identified by the Ontario Ministry of the Environment as a major aquifer. Well yields are high and domestic supplies can be obtained throughout the area underlain by these bedrock units. Municipal supplies at Smithville and at North Pelham are developed in this aquifer. Water quality is variable and can be locally hard and mineralized.

Salina Formation: The Salina Formation consists mainly of dolostone, shale and evaporite deposits (anhydrite, gypsum, halite and sylvite). The upper portion of the Salina is known to be extensively fractured with the fractures widened by secondary solutions of the evaporites. The dissolutioning of the evaporites results in locally high concentrations of calcium, sodium, potassium, sulphate and chloride. Although water quality is generally poor, well yields are typically high and domestic water requirements can generally be met. Municipal supplies at Caledonia are developed in this aquifer.

Bass Island Formation: Only two sites (LF-2C and LF-2E) have been tentatively identified as being located over the Bass Island Formation. The Bass Island dolostones are locally productive. Water quality is variable with elevated sulphate concentrations being common.

Queenston and Georgian Bay Formations: Well yields in these shale formations are generally low and water quality may be poor with unacceptably high chloride concentrations. Most wells are completed in the upper weathered portion of the formations.

3.3.3 SURFACE DRAINAGE

During constraint mapping, major river systems, their associated flood plains, large wetlands and areas of generally poor surface drainage were identified and mapped at a 1:50,000 scale. A detailed description of each feature and its significance to facility siting is presented in Section 2.3.

Stream courses, flood plains and large wetland areas are associated with major constraints necessitating reliance on engineering to contain potential contaminants and/or improve foundation characteristics. Should facilities be developed on lands containing these drainage features, the facilities can be expected to present a risk to human health and the environment. Lands containing stream courses, flood plains and large wetland areas were therefore considered exclsuionary during constraint mapping.

Large areas of poor surface drainage identified during constraint mapping contain numerous small, shallow depressions or swales which are often water filled (wetlands). Many of the wetlands are connected by small streams and many contribute to baseflow. The small wetland areas within the poor surface drainage areas are not expected to pose serious problems to development as they can be completely removed during site preparation.

Additional small stream courses (both intermittent and perennial), flood plains and small wetlands were identified as part of this analysis and mapped on the 1:10,000 scale site area maps. The surface drainage factor has been introduced to qualitatively assess the significance of the identified drainage features on facility development.

3.4 DATA COLLECTION

The existing information base provided in the Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region (GLAL 1984) and candidate area assessments (constraint mapping) described in this report were augmented by reconnais-

sance-level site visits during the winter of 1983-1984. Aerial photographs and topographic maps, at a scale of 1:10,000, were provided by OWMC for each site area or group of site areas. Where sites were continguous, they were often grouped and reviewed together. Field observation forms were prepared to record observations. Examples of the field observation forms and accompanying map are provided in Appendix B, Figures B-1, B-2 and B-3 respectively.

All site areas were visited by a team consisting of a geologist and biologist. A similar set of observation forms and maps were completed on the biology of the site area. Although the site area visits were limited to roadside observations it was possible to develop a general impression of terrain conditions (i.e. landforms, topography) and to field check various terrain features noted in earlier studies and on the aerial photogrpahs (surface drainage, wetlands, etc.).

Field data forms, maps and site photographs for all site areas visited are on file with OWMC.

3.5 FACTOR APPLICATION AND SITE AREA RANKING

The identified factors were applied to:

- differentiate amongst site areas (natural containment potential, aquifer and surface drainage factors);

- re-define the site area boundaries (natural containment potential and surface drainage factors);

- identify constraints to facility development (natural containment potential and surface drainage factors);

- rank the site areas relative to each other (natural containment potential factor);

- ensure a diversity of choice (aquifer and natural containment potential factors).

Although these factors could be used to exclude entire site areas from further consideration, they were primarily used to re-define site area boundaries by excluding constrained portions of the site areas. In the process of boundary re-definition, it is possible that a site area may be dropped because of inadequate site size or poor configuration.

Information collected for the three factors (natural containment potential, aquifers and surface drainage) was interpreted and tabulated (Appendix B, Tables B-1 and B-2). The tabulated information was used to rank site areas and to identify potential constraints to site development. The manner in which the three factors were applied is described below.

3.5.1 NATURAL CONTAINMENT POTENTIAL

Individual site area comparisons are based largely on the natural containment potential of the hydrogeologic settings. A ranking system was developed which reflects the anticipated level of natural containment provided by the site area. Site areas were ranked as "Level 1", "Level 2" and "Level 3". Within each grouping (i.e. "Level 1") all site areas were considered to possess similar containment characteristics.

Table 6 presents a summary of the site area ranking approach developed for this stage of our investigations.

A site area was considered to be "Level 1" where:

- the site is expected to be underlain by silt-clay soils with lateral and vertical textural uniformity;
- the level of confidence in the geologic/hydrogeologic interpretation is high because of a regional pattern of geologic uniformity.

Those sites expected to be underlain by similar soils with the same level of confidence in the geologic/hydrogeologic interpretation but with suspected thinner confining layer thicknesses were grouped as "Level 2".

A "Level 3" site is one expected to be underlain by primarily silt-clay soil with suspected lateral and vertical textural variability. The level of confidence of the data base and interpretation is somewhat lower because of a regional pattern of geologic variability.

Portions of several site areas are underlain by the following constraint features or hydrogeologic conditions:

- moraine features;
- spoil piles;
- areas of less than about 20 m of silt-clay soil (landfill and integrated facilities); and

TABLE 6: RANKING SYSTEM USED IN IDENTIFICATION OF POTENTIAL SITES

NATURAL CONTAINMENT POTENTIAL									RANKING
REGIONAL CATEGORIES					GEOLOGIC MATERIALS		GEOLOGIC PREDICTABILITY		
1A	1B	1C	2A	2B	Lacustrine Silt-Clay	Halton Till	Uniform	Moderate Variability	
LANDFILL INTEGRATED FACILITIES									
X					X	X	X		Level 1
	X				X	X	X		Level 2
			X		X	X		X	Level 3
PHYS/CHEM TREATMENT AND INCINERATOR FACILITIES									
X	X				X	X	X		Level 1
		X			X	X	X		Level 2
			X	X	X	X		X	Level 3

- areas of less than about 10 m of silt-clay soil (physical chemical treatment and incinerator facilities).

The moraine and spoil piles are features identified as a result of the more detailed 1:10,000 scale mapping. Those portions of site areas with insufficient soil thickness (relative to facility requirements) occurred as a result of boundary adjustments due to property acquisition limits.

In order to be consistent with the use of constraint mapping factors, lands underlain by these features and/or conditions are identified here, as representing potentially major constraints to facility development. Such lands should be treated as exclusionary. Table 7 identifies those site areas containing major constraint features and the percent area covered by the constrained lands. The actual constrained lands and features are shown on the site area maps on file with OWMC.

Where such constrained lands make up a large portion of the total site area, the exclusion of these lands may result in the elimination of the site area based on facility size and configuration requirements. Where only a small portion of the total site area is constrained it may still be possible to accommodate the facility by shifting its location within the site area. Generally the site areas are substantially larger than will ultimately be required for facility development. As such these constraint features were not utilized in ranking the various site areas but were identified to assist in assessing site location, size and configuration.

TABLE 7: IDENTIFIED CONSTRAINTS IN SITE AREAS

SITE AREA	IDENTIFIED CONSTRAINT	ESTIMATED % OF AREA COVERED	COMMENTS
PI-1A1	-	-	Flood plain west of site
PI-2A1	Flood plain	<10	Flood plains adjacent to site on two of three sides
PI-3A1	Flood plain	<10	Flood plain crosses SW corner
PI-1N	-	-	None
PI-2N	-	-	None
PI-3N	Moraine/Flood plain	20/<10	Moraine on S. side of site. Flood plain splits site into 1/3 + 2/3, additional flood plain W. side
PI-4N	Moraine	30	Moraine on S. side
PI-5N	Moraine/Flood plain	10/<10	Moraine on S. side of site. Flood plain splits site almost in half
PI-6N	Flood plain	minor	Flood plain E. side of site
PI-10N	Flood plain	<10	Flood plain on W. side
PI-11N	Flood plain	<10	Flood plain cuts off NE corner
PI-12N	-	-	None
PI-13N	-	-	None
PI-14N	Flood plain	<10	Flood plain crosses SW corner
PI-15N	-	-	Flood plain to E. of site
LF-1A1	-	-	Flood plain adjacent to NW side of site
LF-2A1	Flood plain	<10	Flood plain crosses SW corner
LF-1N	-	-	None
LF-2N	Moraine	30	Moraine on S. side of site
LF-3N	Moraine/Flood plain	10/<10	Moraine on S. side. Flood plain splits site almost in half.

TABLE 7 (cont'd)

SITE AREA	IDENTIFIED CONTRAINT	ESTIMATED % OF AREA COVERED	COMMENTS
LF-4N	-	-	None
PI-2W	Flood plain	<10	Site is cut into small sections by three flood plains
LF-2W	Flood plain	<10	Flood plain crosses N. side of site
LF-3W	Flood plain	<10	Flood plain crosses SW corner of site
LF-4W	Flood plain	<10	Site is bisected by flood plain
LF-5W	Flood plain	10	Site is bisected by flood plain
LF-7W	Flood plain	<10	Flood plain on site
LF-10W	Flood plain	<10	Flood plain cuts across NW corner
LF-11W	Flood plain	<10	1/3 of site is fragmented by flood plains
LF-13W	-	-	None
LF-14W	Flood plain	<10	SE corner of site is crossed by flood plain
PI-1C	-	-	None
PI-2C	-	-	None
PI-11C	-	-	None
PI-15C	-	-	None
PI-19C	Flood plain	<10	Flood plain cuts across NW side of site
PI-21C	-	-	None
PI-22C	-	-	None
PI-25C	Flood plain	10	Site is bisected by flood plain
PI-26C	-	-	Flood plain just outside N. + S. margins
LF-1C	-	-	None
LF-2C	-	-	None
LF-3C	-	-	Flood plain just outside N. + S. margins

TABLE 7 (cont'd)

SITE AREA	IDENTIFIED CONSTRAINT	ESTIMATED % OF AREA COVERED	COMMENTS
LF-8C	-	-	None
LF-9C	Flood plain	<10	Flood plain intrudes into south half of site
LF-12C	-	-	None
LF-13C	-	-	None
LF-15C	-	-	None
LF-18C	Flood plain	10	Site is bisected by flood plain
LF-24C	-	-	None
LF-25C	-	-	None
LF-29C	Flood plain	<10	Flood plain crosses S. + W. sides of site
LF-30C	Flood plain	10	Site bisected by flood plain
PI-1E	Spoil	30	Spoil west side of site
PI-2E	Spoil	<10	Spoil SW side
PI-3E	Spoil	10	Spoil southern portion of site
PI-4E	Flood plain	minor	Flood plain runs across N. edge of site
PI-5E	-	-	None
PI-6E	Flood plain	<10	Flood plain cuts off SE corner of site
PI-7E	-	-	None
PI-8E	Flood plain	<10	Site is bisected by flood plain
PI-9E	-	-	None
PI-10E	-	-	None
PI-11E	-	-	Flood plain runs along E. margin of site
PI-12E	Flood plain	minor	Surrounded on 3 sides by flood plain
PI-13E	-	-	Flood plain follows W. margin
PI-14E	Flood plain	<10	Flood plain cuts across W. side
		<20	Shallow Bedrock suspect

TABLE 7 (cont'd)

SITE AREA	IDENTIFIED CONSTRAINT	ESTIMATED % OF AREA COVERED	COMMENTS
PI-15E	Flood plain	minor	Flood plain on E.+ W. margins
PI-16E	-	-	Flood plain outside E.+ W. margins
PI-17E	Moraine	minor	Moraine indications along E. edge of site
PI-18E	-	-	None
PI-19E	Spoil/moraine	30/minor	Spoil N. half of site, moraine indications E. side
PI-20E	-	-	None
PI-21E	Spoil	60	Spoil Central + West part of site
PI-26E	Flood plain/moraine	<10/minor	Flood plain crosses southern-most portion of site, moraine along NE edge
PI-27E	Flood plain	10	Flood plain crosses top of site - Flood plain separates bottom 3rd of site.
PI-30E	Flood plain	10	Site is bisected by flood plain
PI-31E	Flood plain	minor	Flood plain follows W. margin of site
PI-34E	Spoil	40	Site is divided in half by spoil piles + Welland Canal
PI-37E	Flood plain	minor	Flood plain follows part of W. margin
LF-1E	Flood plain	minor	Flood plain follows S. margin of site
LF-2E	Spoil	60	Spoil central + west part of site
LF-3E	Flood plain	<10	Flood plain cuts off SE corner
LF-4E	-	-	None
LF-6E	Spoil	20	Spoil on W. side of site
LF-7E	Spoil/Feeder Canal	40/minor	E. side of site is spoil, Feeder Canal W. side

TABLE 7 (cont'd)

SITE AREA	IDENTIFIED CONSTRAINT	ESTIMATED % OF AREA COVERED	COMMENTS
LF-8E	Spoil/Feeder Canal	30/minor	NE portion of site is spoil, Feeder Canal W. side
LF-9E	Flood plain	minor	Flood plain follows E.+ W. margins
LF-10E	Flood plain	10	Site is bisected by flood plain
LF-12E	Flood plain	minor	Flood plain follows part of W. margin of site

Table 8 represents the site ranking based on the natural containment potential factor. Those sites with major identified constraints (Table 7) are noted with an asterisk. The actual rating (i.e. "Level 1", "Level 2" and "Level 3") applies strictly to the unconstrained portions of the site area.

3.5.2 AQUIFER

Aquifers of variable productivity and water quality are known to exist beneath all site areas. While some site areas are located over major aquifers such as the Guelph-Amabel bedrock formations, it must be recognized that even a marginal aquifer, such as the Queenston Formation, can represent a sole source of water for individuals in a specific area. The use of aquifers as a factor differentiating between site areas must therefore be deferred until the value of the local ground water resource can be established with site specific information. This would necessitate identifying existing and anticipated future ground water uses in the site area, local aquifer characteristics (productivity and water quality) and the availability of alternative water supplies. Because of the difficulties associated with collecting such detailed information for the large number of site areas to be evaluated, emphasis was placed, at this time, mainly on identifying the type of aquifers below each site area (Appendix B, Tables B-1 and B-2). It was therefore possible to ensure that the final selection of potential sites maintained a diversity of choice for future detailed candidate site investigations and subsequent comparison. As such sites were not ranked utilizing this factor.

TABLE 8: RANKING OF SITE AREAS

Landfill/Integrated Site Areas

Level 1	LF-1C	LF-8C	LF-18C *	LF-2E *	LF-8E *
	LF-2C	LF-9C *	LF-29C *	LF-6E *	
		LF-15C	LF-30C *	LF-7E *	
Level 2	LF-1N	LF-3C	LF-1E *	LF-10E *	
	LF-4N	LF-12C	LF-3E *	LF-12E *	
	LF-4W *	LF-24C	LF-4E		
	LF-7W *	LF-25C	LF-9E *		
Level 3		LF-1A1	LF-2W *	LF-11W *	
		LF-2A1 *	LF-3W *	LF-13W	
		LF-2N *	LF-5W *	LF-14W *	
		LF-3N *	LF-10W *	LF-13C *	

Physical/Chemical Treatment and Incinerator Site Areas

Level 1	PI-1N	PI-25C *	PI-17E *	PI-21E *	PI-34E *		
	PI-11C	PI-26C	PI-18E	PI-26E *	PI-37E *		
	PI-15C	PI-6E *	PI-19E *	PI-27E *			
	PI-21C			PI-30E *			
Level 2	PI-2N	PI-13N	PI-22C	PI-4E*	PI-10E	PI-14E	PI-31E*
	PI-10N*	PI-14N*	PI-1E*	PI-5E	PI-11E	PI-15E*	
	PI-11N*	PI-15N	PI-2E*	PI-7E	PI-12E*	PI-16E	
	PI-12N	PI-1C	PI-3E*	PI-8E*	PI-13E	PI-20E	
		PI-2C		PI-9E			
Level 3		PI-1A1		PI-3N *		PI-6N *	
		PI-2A1 *		PI-4N *		PI-2W *	
		PI-3A1 *		PI-5N *		PI-19C *	

* Major identified constraint

3.5.3 SURFACE DRAINAGE

Stream courses (both intermittent and perennial) associated flood plains and wetlands are delineated on 1:10,000 scale site area maps. These maps and accompanying field observation sheets are on file with OWMC.

In keeping with the use of constraint mapping factors, lands underlain by perennial stream courses and flood plains are identified as representing potentially major constraints to facility development. The intermittent streams, drainage swales and wetland areas which have been identified, are small, and are not expected to pose serious problems to development. These areas can be readily drained, and/or excavated to remove poor foundation materials such as organic soils and the surface recontoured using local and/or imported fill materials. Facility development on any site will ultimately require preparation of detailed site drainage plans which need to be integrated into the natural site and site vicinity drainage system. Such plans typically involve modifications to the ground surface.

A three category system was developed to qualitatively assess the level of constraint imposed by the surface drainage of the individual site areas:

(1) site areas with no drainage constraints (i.e. no stream courses, flood plains or wetlands);

(2) site areas with minor drainage constraints (i.e. intermittent stream courses and/or wetlands);

(3) site areas with major drainage constraints (i.e. perennial stream courses and/or flood plains).

Tables B-1 and B-2 in Appendix B present the results of this grouping. The categories were used primarily to identify those site areas that contain constrained lands. The constrained lands (streams and flood plains) are treated as exclusionary. The remaining unconstrained portions of the site areas were then appraised for site size and configuration by the site selection team and either dropped or included for further consideration.

3.6 CONCLUSIONS AND RECOMMENDATIONS

The physical resources factors were used in the identification of potential sites to:

- differentiate amongst the various site areas (all factors);
- establish boundary conditions (natural containment potential and surface drainage factors; and
- rank the various site areas (natural containment potential);
- maintain a diversity of choice between the site areas, the significance of which could be established during future more detailed investigations (natural containment potential and aquifer factors).

Site areas were characterized by the various assemblages of physical features and conditions which may be present (Appendix B, Tables B-1 and B-2). Specific features such as spoil, moraine, stream courses and flood plains (Table 7, Section 3.5), may represent a constraint to facility development in that they are not likely to provide the second level of protection of the environment desired by the OWMC. These constrained lands should be considered accordingly. Site areas were subsequently assessed by the site selection team to establish the adequacy of the remaining unconstrained portions of the site areas from a site size and configuration perspective.

The aquifers below each site area were identified and it was recommended to the site selection team that the final selection of potential sites maintain a diversity of choice for future considerations.

In summary,

(1) *A total of 90 of the 152 site areas were evaluated using physical resource considerations.*

(2) *Of these, thirty-eight (38) identified as a result of the constraint mapping process may potentially be considered for an integrated facility or a landfill.*

(3) *Twelve (12) of the 38 integrated/landfill site areas were ranked as "Level 1" (Table 8, Section 3.5), 14 were ranked as "Level 2" and 12 were ranked as "Level 3".*

(4) *Of the 90 site areas, 52 may potentially be considered for a chemical treatment plant and/or incinerator.*

(5) *Sixteen (16) of the 52 physical/chemical treatment and incinerator site areas were ranked as "Level 1" (Table 8, Section 3.5), 27 were ranked as "Level 2" and 9 were ranked as "Level 3".*

(6) *Some portions of the site areas contained constraints that should be considered exclusionary. These are spoil piles, moraines, stream courses and flood plains. Table 7, Section 3.5 summarizes the site areas affected and maps on file with OWMC depict the specific features. Re-routing of stream courses could serve to mitigate the surface drainage concerns.*

4.0 IDENTIFICATION OF CANDIDATE SITES

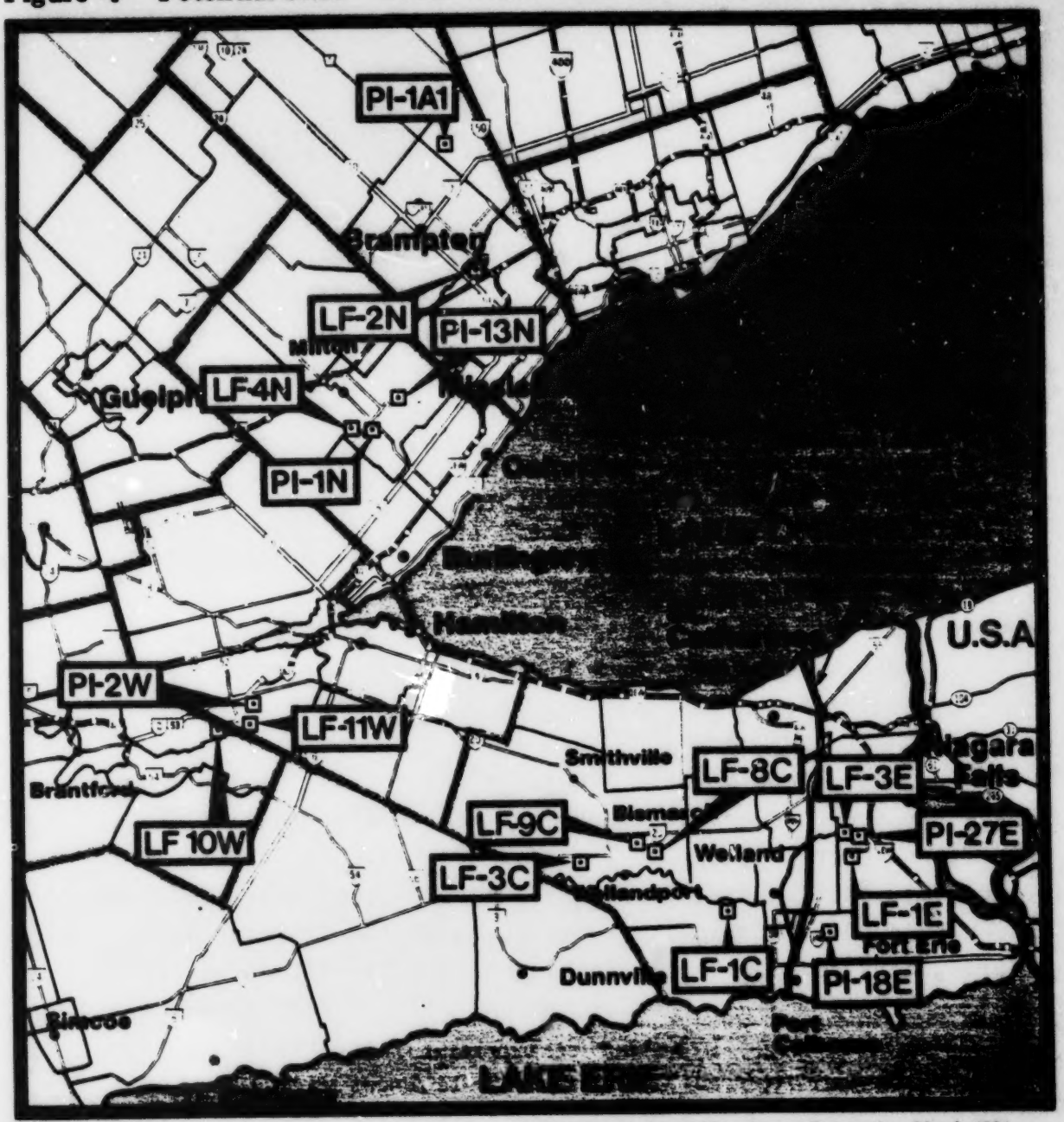
4.1 BACKGROUND

Site area screening resulted in the identification of 16 potential sites. The potential sites are altered in size from the original site areas. Portions of the original site areas were excluded because of multidisciplinary constraints and other lands were added to accommodate an expanded study area around the sites. The locations of the potential sites and the types of facilities that could be developed are shown on 1:10,000 scale maps in Appendix C.

This stage in the site selection process involved consideration of site, site vicinity, access road risk or impacts and costs. Emphasis was placed on the reduction of the list of potential sites to a short list of candidate sites, using the various multidisciplinary factors. Potential access route combinations were introduced at this stage and work was undertaken which facilitated the identification of preferred access routes to the potential sites.

The methodology employed in evaluating the potential sites from a physical resources perspective is described in the following sections.

Figure 4 Potential Sites — From Which Candidate Sites Were Selected



Legend

- Potential Site
- Regional Municipal & County Boundaries
- Township, Town & City Boundaries
- Landfill
- Physical/Chemical Treatment Plant & Incineration

Source: Ontario Waste Management Corporation. March, 1984.
Note: Symbols indicate location only, and not size or shape of sites.

Site Name	Landfill	Physical/ Chemical	Incinerator	
LF-2N	•	•		
LF-4N	•	•		
LF-10W	•	•	•	Integrated
LF-11W	•	•	•	Integrated
LF-1C	•			
LF-3C	•	•	•	Integrated
LF-8C	•	•	•	Integrated
LF-9C	•	•	•	Integrated
LF-1E	•	•	•	Integrated
LF-3E	•	•	•	Integrated
PI-1A1		•	•	
PI-1N		•	•	
PI-13N		•	•	
PI-2W		•	•	
PI-18E		•	•	
PI-27E		•	•	

4.2 FACTOR IDENTIFICATION AND METHODOLOGY

4.2.1 FACTOR IDENTIFICATION

The three physical resources factors -- "Natural Containment Potential", "Aquifer" and "Surface Drainage" used during site screening were carried forward into this stage (initial) comparative evaluation. During site screening, these factors were used to differentiate between, and provide a relative ranking of, the various site areas. Their applicability to this stage in the process is related to:

- the need to compare the individual potential sites; and to
- the necessity to use site specific information that can be drawn from the existing data base and from brief roadside visits.

One additional factor identified as "Sensitive Lands", was introduced to provide input to the establishment of preferred access routes to the candidate sites. This factor addresses the concerns associated with the accidental spillage of wastes, during transit and is based on the approach taken during constraint mapping (Section 2.5). The factor was used to qualitatively compare the potential access routes based on the natural capability of soils along these routes to contain such accidental spillage.

4.3 FACTOR DESCRIPTIONS AND RATIONALE

The "Natural Containment Potential" factor was modified to include two additional indicators - "confining layer thick-

ness" and "oil and gas wells". The confining layer thickness indicator refers to the average thickness of the uppermost surficial layer of fine grained materials (silt-clay textured). Contaminant migration is very slow through such materials. As the thickness of the confining layer increases, the travel time for contaminants similarly increases.

The confining layer thickness indicator represents a refinement of the regional category indicator. While the regional category indicator is based on regional trends in geologic materials, the confining layer thickness indicator is based on local site specific geologic information available from water well records.

The oil and gas well indicator addresses those concerns related to the vertical migration of contaminants through damaged or corroded well casings to aquifers. Abandoned oil and gas wells, which have not been properly sealed, can act as conduits through which contaminants can potentially move to productive water bearing zones (aquifer).

The presence of oil and gas wells is not considered to be a major constraint to facility siting. Although abandoned oil and gas wells are a concern to development, this concern can be eliminated by locating and properly sealing all wells in the vicinity of a proposed site.

The aquifer factor is fully described in Section 3.3.2 and 3.5.2. Emphasis during this stage was placed on identifying the type of aquifer present. The presence of an aquifer is not considered a constraint to siting since all sites are located over some type of an aquifer. It is recognized that even a

marginal aquifer, such as the Queenston Formation, can represent a sole source of water for individuals in a specific area. The aquifer factor was used to ensure a diversity of choice during subsequent stages of the site selection process when more detailed site specific information will be available.

The "Surface Drainage" factor was extensively modified and now encompasses site specific considerations in relation to surface drainage efficiency, potential drainage constraints and ease of implementing surface drainage controls if required. The factor and the indicators used in completing the surface drainage evaluation are described in detail in Appendix E and the factor sheet is presented in Appendix A.

The "Sensitive Lands" factor used in comparison of the various site access routes addresses the potential for the subsurface migration of any contaminants spilled along the access routes.

Sensitive lands are identified as those lands along the access routes which may be underlain by:

- bedrock at or near surface;
- granular at or near surface;
- floodplain deposits (generally variable texture);
- man-made fill (such as excavation material from the Welland Canal -- variable texture).

4.4 DATA COLLECTION

Potential site maps at a scale of 1:10,000 showing site boundaries were provided to the site selection consulting

teams. A 500 m study area was established around the landfill and a study area of 1000 m was established around the physical chemical treatment plant and incinerator for the comparative analysis of emission receptors. Access route maps at a scale of 1:50,000 were also provided. The study areas were altered from the original site areas as a result of the expanded study area and the exclusion of those portions of the site areas that were extensively constrained. In some instances, however, it was necessary to include a specific constraint feature, such as a floodplain, within the site boundary because of property acquisition limits. This was done with the understanding that the constrained lands would not be used for facility siting but rather may form part of the technical buffer to be established around the facility.

Although the physical resources studies were essentially limited to the sites, site vicinities and access routes, existing information from beyond the study area was also taken into consideration in the analysis. The methodology and sources of information used in undertaking the physical resources studies are discussed in the following sections.

4.4.1 NATURAL CONTAINMENT POTENTIAL AND AQUIFER(S)

Briefly stated, during the initial comparative evaluation all previously collected information which may have some bearing on the natural containment potential and aquifer factors was re-examined and evaluated from a site specific basis.

Initially, this involved the re-appraisal of regional patterns in geology to identify smaller scaled local features. Features identified during site area mapping were transferred

to the 1:10,000 scale bases. Water well information provided on MOE computer printouts (current to December 1980) was reviewed, as were the 1:10,000 scale aerial photographs used during site screening. It is not uncommon for site specific information to indicate local anomalies which are not readily apparent at a regional scale. For example, it was possible to refine the confining layer thickness data collected in identification of candidate areas, by using "clay" thicknesses recorded in local water well records. In one instance, at LF-3E, the regional trend indicated that the confining layer is at least 20 m thick and thus suitable for landfilling (20 m of fine-textured soil is being used as a general minimum thickness "guideline" for assessing a site suitability for landfilling). Upon closer examination of the underlying clay", thickness was established to range from 10-34 m and averaged less than 20 m below the site.

The well records were also used to provide local information in stratigraphic relationships (for assessment of geologic uniformity) and to identify which geologic units provide the major source of ground water to domestic wells (for identification of aquifers).

Information on the distribution of known oil and gas fields and on well density was obtained from the Ontario Ministry of Natural Resources (MNR). Local wells were noted in the field during the road side visits. It should be noted that in many instances, particularly for older abandoned wells no surface evidence of casing may exist. Many of these older wells have also not been recorded by MNR. It would be necessary to undertake a more detailed on-site survey to establish the presence of abandoned wells through discussion with local residents.

A discussion of the geology, hydrogeology and physical terrain conditions for each of the 16 potential sites is provided in Appendix C.

4.4.2 SURFACE DRAINAGE

The surface drainage evaluation was undertaken by Dillon Consulting Engineers and Planners and is described in their report (Appendix E).

The work involved a windshield survey of each site and an evaluation of existing floodplain mapping. Sites were photographed during melt/runoff conditions (February 1984) to discuss potential drainage/flooding problems.

4.4.3 SENSITIVE LANDS

The analysis of transportation access routes is based on the distance travelled over sensitive lands (as defined in Section 4.3) between 400 series highways and potential sites.

Alternative access routes were identified by the site selection team transportation consultant on 1:50,000 scale topographic map bases. Those segments of the alternative access routes underlain by sensitive lands were identified on these bases.

Information on the surficial geology along the access routes is available from published geology maps and from the constraint mapping described in this report.

The actual linear distance that the access routes (both local and regional roads) cross over these sensitive land segments was calculated.

The information for alternative access routes was provided to the OWMC in tabular form and is presented in Appendix D.

4.5 FACTOR APPLICATION

The factors were used to:

- differentiate amongst potential sites and alternative routes (all factors);
- to identify constraints to facility development (natural containment potential and surface drainage factors);
- rank the potential sites, alternative access routes and siting options relative to each other (natural containment potential, sensitive lands and surface drainage factors).

The manner in which each of the four factors were applied is described in the following sections.

4.5.1 NATURAL CONTAINMENT POTENTIAL

The natural containment potential factor played a major role in the ranking of the potential siting options. Table 9 presents the ranking system developed for this factor. The use of site specific water well information during the identification of candidate sites resulted in an adjustment in the weighting placed on the factor indicators carried forward from site area screening. The regional category indicator, which incorporates the four category classification system developed during the identification of candidate areas was superseded in ranking of the sites by the confining layer thickness and geologic predictability indicators. These two indicators incorporate site specific information and conse-

TABLE 9: RANKING SYSTEM USED IN IDENTIFICATION OF CANDIDATE SITES
- NATURAL CONTAINMENT POTENTIAL FACTOR

NATURAL CONTAINMENT POTENTIAL								
AVERAGE CONFINING LAYER THICKNESS (m)				GEOLOGIC MATERIAL TEXTURE		GEOLOGIC PREDICT-ABILITY		RANKING
>30	20-30	10-20	<10	Silt-Clay	Till	Uniform	moderate variability	
Landfill/Integrated Facilities								
X				X	X	X		Level 1
	X			X	X	X		Level 2
X	X			X	X		X	Level 3
		X	X	X	X	X	X	Major constraint
Physical-Chemical and Incinerator Facilities								
X	X			X	X	X		Level 1
		X		X	X	X		Level 2
X	X	X		X	X		X	Level 3
			X	X	X	X	X	Major constraint

quently are more representative of subsurface conditions in the vicinity of the potential sites.

The oil and gas well indicator was initially introduced to identify potential pathways for contaminant migration (see Section 4.3). It was established however that the data base could not be adequately completed without conducting more detailed site work. This indicator was therefore used only in a general manner to differentiate between the potential sites (Table 10).

Table 11 presents the site ranking based on the natural containment potential factor. The potential sites are ranked as "Level 1", "Level 2", "Level 3" or "Major Constraint". The "Level 1" and "Level 2" sites are differentiated strictly on the basis of confining layer thickness. These sites are underlain by consistent silt-clay soils which are considered to provide the desired second level of environmental protection. A "Level 3" site is underlain by soils of variable thickness which are somewhat less consistent. The "Major Constraint" ranking was applied in only one instance - LF-3E. This site is underlain by less than the 20 m minimum confining layer thickness used as a general planning guideline for site acceptability for landfilling.

4.5.2. AQUIFER

The aquifer factor was not used in the ranking of potential sites but rather was applied in a general manner to maintain a diversity of choice in the process of narrowing the list of potential sites to a shorter list of candidate sites. This

TABLE 10: OIL AND GAS WELL CONSIDERATIONS

POTENTIAL SITE	COMMENTS
LF-2N	no wells observed, low well density, no gas fields
LF-4N	no wells observed, low well density, no gas fields
PI-1A1	no wells observed, low well density, no gas fields
PI-1N	no wells observed, low well density, no gas fields
PI-13N	no wells observed, low well density, no gas fields
LF-10W	no wells observed, low well density, no gas fields
LF-11W	no wells observed, low well density, no gas fields
PI-2W	no wells observed, low well density, no gas fields
LF-1C	no wells observed, low well density, local gas fields
LF-3C	no wells observed, low well density, local gas fields
LF-8C	no wells observed, low well density, local gas fields
LF-9C	no wells observed, low well density, local gas fields
LF-1E	one gas well, low well density, local gas fields
LF-3E	two gas wells, low well density, local gas fields
PI-18E	no wells observed, moderate well density, local gas fields
PI-27E	two gas wells, low well density, local gas fields

TABLE 11: RANKING OF POTENTIAL SITES BASED ON THE NATURAL CONTAINMENT POTENTIAL FACTOR

SITE AREA	NATURAL CONTAINMENT POTENTIAL								
	AVERAGE CONFINING LAYER THICKNESS (m)				GEOLOGIC MATERIAL TEXTURE		GEOLOGIC PREDICT-ABILITY		
	>30	20-30	10-20	<10	Silt Clay	Till	Uniform	Mod.** Var.	RANKING
LF-2N		X				X		X	Level 3
LF-4N		X				X	X		Level 2
PI-1A1		X				X		X	Level 3
PI-1N			X			X	X		Level 2
PI-1N North			X			X	X		Level 2
PI-1N South			X			X	X		Level 2
PI-13N*			X			X	X		Level 2
LF-10W		X			X			X	Level 3
LF-10aW		X			X			X	Level 3
LF-10bW		X			X			X	Level 3
LF-11W		X			X			X	Level 3
PI-2W		X			X			X	Level 3
LF-1C	X				X		X		Level 1
LF-3C		X			X		X		Level 2
LF-8C	X				X		X		Level 1
LF-9C	X				X		X		Level 1
LF-1E		X			X		X		Level 2
LF-1aE		X			X		X		Level 2
LF-1bE		X			X		X		Level 2
LF-3E			X		X		X		MAJOR CONSTRAINT
PI-18E		X			X		X		Level 1
PI-27E			X		X		X		Level 2

* Portion of site may have less than 10 m of confining layer, possible that site may have major constraint

** Moderate Variability

approach was also used during site area screening (Section 3.5.2). The major sources of ground water supply (aquifers) in the vicinity of each of the potential sites is listed in Table 12. A description of the various aquifers is provided in Section 3.3.2.

4.5.3 SURFACE DRAINAGE

The approach used in application of the surface drainage factor and the results of the surface drainage evaluation are presented in the Dillon report (Appendix E). A summary ranking of the potential sites is provided in Table E-2 of the Dillon Report (Appendix E).

4.5.4 SENSITIVE LANDS

The sensitive lands factor was used strictly to facilitate the identification of preferred access routes to the potential sites. This factor was not used in ranking of the various site options because:

- it plays a less significant role, compared to the natural containment potential and surface drainage factors in assessing the relative suitability of a site with respect to goals of minimizing risk to human health and impacts to the environment;
- accidental spills are to be mitigated immediately by an emergency response spill clean-up team;
- access routes can be changed to cross less sensitive lands (the site location cannot be readily changed following selection).

TABLE 12 PRINCIPAL SOURCES OF GROUND WATER SUPPLIES (AQUIFERS) IN THE VICINITY OF THE POTENTIAL SITES.

SITE	AQUIFER
LF-2N	most wells completed in granular materials immediately above the bedrock or in the upper fractured portion of the bedrock (Queenston and Georgian Bay formations)
LF-4N PI-1N PI-13N	most wells completed in granular materials immediately above the bedrock or in the upper fractured portion of the bedrock (Queenston Formation)
PI-1A1	most wells completed in granular above the bedrock (Georgian Bay Formation)
LF-10W LF-11W PI-2W	most wells completed in the bedrock (Guelph Formation), some local large diameter wells are completed in the overlying lacustrine - till materials
LF-8C LF-9C	most wells completed in granular materials immediately above the bedrock or in the bedrock (Guelph Formation)
LF-1C LF-3C LF-1E LF-3E PI-18E PI-27E	most wells completed in granular materials immediately above the bedrock or in bedrock (Salina Formation)

Alternative routes (both local and regional roads) to the sites were ranked relative to other routes according to the linear distance of sensitive lands crossed by the route. Table D-1, Appendix D presents the results of this ranking. The highest ranking (i.e. least constrained) was assigned to the alternative route that crosses the smallest distance of sensitive lands.

Preferred routes, as selected by the site selection team using multidisciplinary factors, including the sensitive lands factor have also been identified in Table D-1, Appendix D. No further analysis of the preferred routes was undertaken.

4.6 SITING OPTIONS RANKING

Seventeen siting options encompassing the sixteen potential sites were identified by the site selection team. Each siting option includes a site(s) which can accommodate a landfill and physical/chemical and incinerator plants, and the preferred access routes to these facilities.

Only two factors, "natural containment potential" and "surface drainge" were used in ranking of the seventeen siting options. Access route information was not used in this study to rank the siting options. The ranking system is shown in Table 13 and the results are presented in Table 14. In the case of partially integrated options, where the landfill, physical/chemical treatment and incinerator plants are located on different sites (LF and PI sites), and a different ranking was applied to each site, the composite ranking assigned to the siting option is that applied to the lower ranked of the

TABLE 13: RANKING SYSTEM USED IN DIFFERENTIATING AMONGST SITING OPTION RANKING

NATURAL CONTAINMENT POTENTIAL				SURFACE DRAINAGE			RANKING
Level 1	Level 2	Level 3	MAJOR CONST. *	Level 1	Level 2	Level 3	
X				X	X		Level 1
	X			X	X		Level 2
X	X	X		X	X	X	Level 3
			X	X	X	X	MAJOR CONSTRAINT

* MAJOR CONSTRAINT

Explanatory note: Natural Containment Potential and Surface Drainage factor ranking results established for the candidate sites, are presented in Table 11 on Page 92 and in Table E-2 of Appendix E. These separate factor rankings are used above to establish a composite ranking for the various siting options. For example, where a candidate site was assigned a "Level 1" for natural containment potential (Table 11) and either a "Level 1 or a Level 2" for surface drainage (Table E-2 of Appendix E), the composite ranking for that site is "Level 1".

As another example, where a candidate site was assigned a "Level 1" for natural containment potential and "Level 3" for surface drainage, the composite ranking for that site is "Level 3". See Table 14 on Page 97.

TABLE 14 - RANKING OF SITING OPTIONS

SITING OPTION	NATURAL CONTAINMENT POTENTIAL RANKING	SURFACE DRAINAGE RANKING	COMPOSITE RANKING
LF-2N/PI-1A1	Level 3	Level 1	Level 3
LF-2N/PI-1N	Level 3	Level 2	Level 3
LF-2N/PI-13N*	Level 3	Level 1	Level 3
LF-4N	Level 2	Level 1	Level 2
LF-4N/PI-1N	Level 2	Level 2	Level 2
LF-4N/PI-13N*	Level 2	Level 1	Level 2
LF-10W	Level 3	Level 1	Level 3
LF-10W/PI-2W	Level 3	Level 1	Level 3
LF-11W	Level 3	Level 1	Level 3
LF-11W/PI-2W	Level 3	Level 1	Level 3
LF-1C/PI-18E	Level 1	Level 3	Level 3
LF-3C	Level 2	Level 2	Level 2
LF-8C	Level 1	Level 2	Level 1
LF-9C	Level 1	Level 2	Level 1
LF-1E	Level 2	Level 2	Level 2
LF-1E/PI-27E	Level 2	Level 2	Level 2
LF-3E	MAJOR CONSTRAINT	Level 2	MAJOR CONSTRAINT

* Portion of site may have less than 10 m of confining layer, possible that site may have major constraint

individual sites. In otherwords, where a "Level 1" site is combined with a "Level 2" site the composite ranking is "Level 2".

A total of seven site options were ranked as either "Level 1" (2) or "Level 2" (5). the individual integrated or partially integrated sites are underlain by uniform silt-clay soils of acceptable thicknesses (relative to facility requirements - Section 1.5.3). These sites also have favourable surface drainage characteristics.

Nine site options were ranked as "Level 3". These options are identified as possessing hydrogeologic and/or surface drainage characteristics which may, following more detailed analysis, reveal major constraints to facility development.

One integrated site, LF-3E, was ranked as "Major Constraint". The silt clay soils which underlie the site appear to be much less than 20 m. Twenty metres of fine textured soils is being used as a minimum guideline for assessing site suitability for landfilling.

4.7 CONCLUSIONS AND RECOMMENDATIONS

The geology, hydrogeology and physical terrain conditions for each of the 16 potential sites are described in Appendix C. Surface drainage characteristics for these sites are described in Appendix E.

Four factors, "natural containment potential" "aquifer", "surface drainage" and "sensitive lands" were identified in order to:

- differentiate amongst potential sites and alternative access routes (all factors);

- to identify constraints to facility development (natural containment potential and surface drainage factors);

- rank the potential sites, alternative routes and siting options relative to each other (natural containment potential, sensitive lands and surface drainage factors).

Information specific to each of these factors was collected and summarized in tabular form for comparative purposes (Tables 10, 11, 12 and Table E-2 in Appendix E). Two factors - natural containment potential and surface drainage were used in ranking the sites. The aquifer factor was carried forward from site area screening and it was recommended that it be used to maintain a diversity of choice for future considerations. The sensitive lands factor was used to compare alternative access routes and to identify preferred access route options.

In summary,

(1) a total of 17 siting options (includes 16 potential sites and alternative access routes) were evaluated;

(2) of these, 2 siting options were ranked as "Level 1" 5 as "Level 2" and 9 as "Level 3".

(3) *one site - LF-3E was ranked as "Major Constraint". This site is underlain by less than the 20 m minimum of fine textured soil thickness used as a general guideline for landfilling. The shallow soil conditions are anticipated to represent a constraint to future development and it is recommended that this site not be carried forward to Phase 4.*

5.0 REFERENCES AND BIBLIOGRAPHY

Anonymous
1935: Soil Survey Map of County of Welland, Province of Ontario, Soil Survey Report No. 5; Ontario Department of Agriculture, Guelph and Dominion Department of Agriculture, Ottawa.

Chapman, L.J. and D.F. Putnam
1966: The Physiography of Southern Ontario (Second Edition); Ontario Research Foundation, published by University of Toronto Press, 386 p.

.....
1972: Physiography of the South Central Portion of Southern Ontario; Ontario Department of Mines and Northern Affairs and the Ontario Research Foundation, Map 2226.

Cowan, W.R.
1972: Pleistocene Geology of the Brantford Area, Southern Ontario; Ontario Department of Mines and Northern Affairs, Industrial Mineral Report 37, 66 p.

Cowan, W.R., D.R. Sharpe, B.H. Feenstra and Q.H.J. Gwyn
1978: Glacial Geology of the Toronto-Owen Sound Area; p. 1-16 in Toronto '78 Field Trips Guidebook, Geological Society of America/ Geological Association of Canada Joint Meeting, Toronto, 1978, 361 p.

M.M. Dillon Limited
1984: Technical Report - Site Selection. Report prepared for Ontario Waste Management Corporation, August 1984.

.....
1984: Technical Report - Transportation. Report prepared for Ontario Waste Management Corporation, August 1984.

Environment Canada, Lands Directorate
Wetland Mapping Series

Feenstra, B.H.
1974: Quaternary Geology of the Dunnville Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.981.

Feenstra, B.H.
1975: Quaternary Geology of the Grimsby Area, Southern Ontario; Ontario Division of Mines, Preliminary Map P.993

Feenstra, B.H.
1981a Quaternary Geology and Industrial Minerals of the Niagara-Welland Area, Southern Ontario; Ontario Geological Survey, Open File Report 5361, 260 P.

.....
1981b: Bedrock Topography of the Dunnville Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2402.

.....
1981c: Bedrock Topography of the Grimsby Area, Southern Ontario; Ontario Geological Survey, Preliminary Map P.2401.

Funk, Gunther
1979: Geology and Water Resources of the East and Middle Oakville Creeks, IHD Representative Drainage Basin; Ontario Ministry of the Environment, Water Resources Report 12, 68 p.

Gartner Lee Associates Limited
1980: Hydrogeological Studies, Halton Regional Landfill Site; A Report Submitted to M.M. Dillon Limited and the Region of Halton, March 31, 1980, 29 p. plus appendices.

.....
1980: Detailed Hydrogeological Study, Niagara-on-the-Lake Landfill Site; Report prepared for Proctor & Redfern Limited, 26 p. plus appendices, May 20, 1980.

.....
1982a: Stage 1 Report Hydrogeological Study South Cayuga Site; Report prepared for Ontario Waste Management Corporation, January 1982.

.....
1932b: Primary Environmental Information, Part 1, Geological/Hydrogeological Inventory Report prepared for Ontario Waste Management Corporation, August 1982, 20 p.

.....
1982c: Primary Environmental Information, Geological/Hydrogeological Inventory; Appendix, Data Resource Sheets, Volumes 1 and 2, Report prepared for Ontario Waste Management Corporation, October 1982.

.....
1983a: Draft Report on Priority of Study of Zone 1 and 2 Lands, Golden Horseshoe, Geologic Considerations; Report prepared for Ontario Waste Management Corporation, April 1983, 24 p.

.....
1983b: Hydrogeological Considerations for Facilities Siting. Report prepared for Ontario Waste Management Corporation, May 1983.

.....
1984: Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region; Draft Report prepared for Ontario Waste Management Corporation, March 1984, 48 p. and Appendices.

Gillespie, J.E., R.E. Wickland and M.H. Miller
The Soils of Halton County, Report No. 43 of the Ontario Soil Survey; Canada Department of Agriculture, Ottawa and Ontario Department of Agriculture and Food, Toronto.

Ontario Ministry of Natural Resources
1983b: Cambridge District Land Use Guidelines, Cambridge, Ontario. 55 pp.

.....
1983c: Maple District Land Use Guidelines. Maple, Ontario. 53 pp.

.....
1983d: Niagara District Land Use Guidelines. Fonthill, Ontario. 52 pp.

..... Hazard Land Maps, Approximate Scale 1:15840.

Ontario Waste Management Corporation
1982a: Facilities Development Process, Phase I Report; September 1982, 42 pp.

.....
1983a: Facilities Development Process, Phase 2 Report; January 1983, 58 pp.

.....
1983b: Facilities Development Process, Phase 3 Interim Report; May 1983, 42 p.

.....
1983c: Map Portfolio, Phase 3 Interim Report; May 1983, 10 maps.

.....
1984: Facilities Development Process, Phase 3 Report; March 1984, 95 p.

Presant, E.W., R.E. Wicklund and B.C. Mathews
1965: The Soils of Wentworth County, Report No. 32 of the Ontario Soil Survey; Canada Department of Agriculture, Ottawa and Ontario Department of Agriculture, Toronto.

Regional Municipality of Haldimand-Norfolk
1980: The Official Plan for the Haldimand-Norfolk Planning Area. November, 1980.

Regional Municipality of Halton
1978: Environmentally Sensitive Area Study, Planning Department, Regional Municipality of Halton, Oakville, Ontario. 261 pp.

.....
1982: The Regional Plan - Official Plan for the Halton Planning Area. December, 1982.

.....
1976: Resource Recovery Study, Interim Report; Report prepared for the Regional Municipality of Halton by M.M. Dillon Limited in conjunction with Gartner Lee Associates Limited, February 6, 1976, 114 p. plus appendices.

Regional Municipality of Hamilton-Wentworth
1982: Official Plan. September, 1982.

Regional Municipality of Niagara
1981: Policy Plan for Regional Niagara. November, 1981.

Regional Municipality of Peel
1975: Solid Waste Management Study, Volume 1, Identification of the Problem; Report prepared for the Regional Municipality of Peel by Proctor & Redfern Limited in conjunction with Gartner Lee Associates Limited, April 11, 1975, 122 p.

Vos, M.A.
1969a Drift Thickness of the Grimsby Sheet, Southern Ontario; Ontario Department of Mines, Preliminary Map p. 536.

.....
1969b: Drift Thickness of the Niagara Sheet, Southern Ontario; Ontario Department of Mines, Preliminary Map p.537.

Watt, A.K.
1968: Pleistocene Geology and Ground Water Resources, Township of Etobicoke; Ontario Department of Mines, Geological Report 59, 50 p.

Wickland, R.E. and B.C. Matthews
1963: The Soil Survey of Lincoln County, Report No. 34 of the Ontario Soil Survey, Research Branch, Canada Department of Agriculture, Toronto and Ontario Department of Agriculture, Ottawa.

FLOOD PLAIN MAPPING RECEIVED OR REVIEWED FROM THE FOLLOWING AGENCY CONTACTS (CONTACT DATES NOTED)

Credit Valley Conservation Authority
Ms. Rose Menyes: October 1983

Delcan (De Leuw Cather, Canada Limited)
Mr. K. Hodges: February 1983

Grand River Conservation Authority
Mr. D. Greer: October 1983

Halton Region Conservation Authority
Mr. J. Hall: August-October 1983

Marshall Macklin Monaghan Limited
Mr. L. Kentridge: October 1983

Metropolitan Toronto and Region Conservation Authority
Ms. Linda Cholmondeley: November-December 1983

M.M. Dillon Limited, Consultants
Mr. A. Mitchel: July 1983-February 1984

Niagara Peninsula Conservation Authority
Mr. C. Leuty: July-November ±983
Ms. B.M. Guyatt: April-November 1983
February 1984
Mr. P. Parker: July, November 1983

Proctor & Redfern Limited, Consultants
Mr. D. Banister: October 1983
February 1984

OTHER CONTACT AGENCIES:

Ontario Institute of Pedology, Guelph
Mr. B. Vanden Broeck: July 1983-
February 1984
Mr. C. Acton: October 1983

APPENDIX A

FACTOR SHEETS

APPENDIX A - FACTOR SHEETS

CONTENTS

		PAGE
A-1	FACTORS USED IN IDENTIFICATION OF SITE AREAS	
	A.1.1 TILL AND LACUSTRINE CLAY PLAIN	A-1
	A.1.2 DRUMLIN (HALTON)	A-3
	A.1.3 POOR SURFACE DRAINAGE	A-5
	A.1.4 MORAINE	A-7
	A.1.5 DRUMLIN FIELD	A-9
	A.1.6 DRUMLIN (NIAGARA)	A-11
	A.1.7 WETLAND	A-13
	A.1.8 SURFACE GRANULAR SOIL	A-15
	A.1.9 FLOOD PLAIN	A-17
	A.1.10 STREAM COURSE	A-19
A-2	FACTORS USED IN IDENTIFICATION OF POTENTIAL SITES	
	A.2.1 NATURAL CONTAINMENT POTENTIAL	A-21
	A.2.2 AQUIFER	A-23
	A.2.3 SURFACE DRAINAGE	A-25
A-3	FACTORS USED IN IDENTIFICATION OF CANDIDATE SITES (SITE COMPARISON)	
	A.3.1 NATURAL CONTAINMENT POTENTIAL	A-27
	A.3.2 AQUIFER	A-29
	A.3.3 SURFACE DRAINAGE	A-31
A-4	FACTOR USED IN IDENTIFICATION OF CANDIDATE SITES (ACCESS ROUTES)	
	A.4.1 SENSITIVE LANDS	A-33

A.1.1 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	TILL AND LACUSTRINE CLAY PLAIN

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Level to gently rolling areas of silty clayey soils that are primarily glaciolacustrine origin in the Niagara Peninsula and glacial till in Halton area.

RATIONALE/SIGNIFICANCE:

The fine grained soils of these areas should act to inhibit the movement of contaminants in the subsurface, particularly in those areas identified in the geological priorities study as potentially having the best hydrogeological conditions for siting facilities. Hence, the possibility of adverse effects to ground water and surface water resources is considered low. This feature provides a second level of protection.

SOURCES OF INFORMATION:

Published geologic literature, as referenced in the Gartner Lee reports to OWMC:

1. 'Geologic and Hydrogeologic Inventory of the Golden Horseshoe Region.
2. Priority of Study of Zone 1 and 2 Lands - Golden Horseshoe - Geological Considerations.
3. Primary Environmental Information Geological/Hydrogeological Inventory Appendix Data Resource Sheets Vols. I & II.
4. Additional sources include 1980, 1:50,000 scale airphotos and limited field checks. See bibliography.

INTERPRETATION/METHODOLOGY:

This factor has been used in the earlier Phase I and II geological and hydrogeological assessments for OWMC. It is within these areas that the zones having the highest geological priority for siting facilities have been identified. It appears as the largest unit on the physical resource maps.

A.1.1 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	TILL AND LACUSTRINE CLAY PLAIN

CRITERIA/INDICATORS:

Previously identified in earlier studies.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Within these large geologic units there is potential for subsurface variability in certain areas. These have been identified in the geologic and hydrogeologic inventory and priorities studies.

A.1.2 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN (HALTON)

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

The drumlins are distinct elongated and often oval shaped hills that are readily identifiable on aerial photographs. They are diagnostic of past glacial ice movement and their long axes are aligned in a parallel direction to that movement.

RATIONALE/SIGNIFICANCE:

The drumlins in Halton consist of the same fine grained silty to clayey Halton Till that occurs in the surrounding areas. As such, they should have the same significance for siting facilities as described under the Till and Lacustrine Clay Plain factor except for the potential of more severe local slopes. As such this feature provides a second level of protection to human health and the environment.

SOURCES OF INFORMATION:

1980 1:50,000 scale aerial photogrpahy, limited field checks and published geological literature as referenced: 1. Geologic and Hydrogeologic Inventory of the Golden Horseshoe. 2. Priority of Study of Zone 1 and 2 Lands - Golden Horseshoe - Geological Considerations. 3. Primary Environmental Information Geological/ Hydrogeological Inventory Appendix Data Resource Sheets Vols. I & II.

INTERPRETATION/METHODOLOGY:

This factor has already been incorporated into the earlier Phase I and II geological and hydrogeological studies. The drumlins are discussed here and shown on the Terrain Conditions Map to add to the completeness of the surficial geological history of the area.

A.1.2 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN (HALTON)

CRITERIA/INDICATORS:

Shape and orientation direction of long axis is diagnostic of these features, which were laid down beneath moving glaciers.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Because of the fine grained nature of the geologic materials comprising these features, the drumlins of Halton may have very little significance for facilities siting. The materials in these features will potentially retard the movement of contaminants in the sub-surface. In this regard they are no different than the surrounding clay till soils.

A.1.3 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	POOR SURFACE DRAINAGE

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Areas of the Haldimand Clay Plain which contain numerous shallow depressions (swales) often with poorly developed drainage patterns. These depressions may contain shallow organic soils and may contain surface water for most of the year.

RATIONALE/SIGNIFICANCE:

The individual wetland features found within this area are not of high significance to location and construction of facilities. They may require drainage and other engineering works (i.e. excavation and filling), or remedial measures to control potential effects.

SOURCES OF INFORMATION:

1980, 1:50,000 scale airphotos and limited ground checking,
Soil Survey Reports.

INTERPRETATION/METHODOLOGY:

Areas encompassed by this poor surface drainage condition are identifiable on the aerial photographs by the presence of small wetland swales. This condition had not been identified or mapped in earlier phases of the work. It is mapped here as a possible minor human environmental or construction concern if facility sites are located on or adjacent to individual depressions.

A.1.3 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	POOR SURFACE DRAINAGE

CRITERIA/INDICATORS:

Areas of poor drainage are often noted as areas where farmers have not cultivated within general crop areas and may show locally wet conditions in depression type topography. A mottled land pattern on panchromatic airphotos is often visible.

The intensity or density of wetland depressions may vary from one area to another within the poorly drained lands; e.g. they may only occupy 5% to 10% of the land area at some locations, while in others 25% or more of a given area may have this condition. Individual wetlands are small and their size is often estimated at less than 1 or 2 ha.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The exact geologic origin of this phenomenon is not known but it is apparently a surface condition only. The feature may downgrade the suitability of the land for agriculture due to the poor and unimproved surface drainage. This feature is not regarded as a serious condition, since the physical effects do not appear to extend to any great depth.

A.1.4 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING: PHYSICAL RESOURCES	FACTOR: MORAINE

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR: These features are usually aligned in a linear fashion and in some instances have a ridged topographic shape (e.g. Trafalgar Moraine in Halton). They are primarily composed of glacial till materials that were deposited along an ice marginal position. Lenses and pockets of granular materials may be associated with these features, occurring either at the surface or buried beneath the till.

RATIONALE/SIGNIFICANCE:

The possible inclusion of lenses and pockets of granular soils could provide potential migration paths for off-site contaminant movement. The geological history suggests the possible occurrence of variable subsurface conditions. The likelihood of sites proving acceptable in this feature, after detailed drilling, is low.

SOURCES OF INFORMATION:

1980, 1:50,000 scale aerial photography, limited field checks and published geological literature as referenced. 1. Geologic and Hydrogeologic Inventory of the Golden Horseshoe Region. 2. Priority of Study of Zone 1 and 2 Lands - Golden Horseshoe - Geological Considerations. 3. Primary Environmental Information Geological/Hydrogeological Inventory Appendix Data Resource Sheets Vols. I and II.

INTERPRETATION/METHODOLOGY:

The possibility that moraines exist, that are not noted in the Literature, represents a concern to the siting of facilities in certain additional areas. In this regard the Candidate Area south of Brampton may be affected by a possible extension of the Trafalgar Moraine. Likewise a small moraine near Drumquin, about 4 km west of Streetsville, potentially raises the same type of concern. All suspected moraines are shown on the Terrain maps appended to this report.

A.1.4 - FACTORS USED IN IDENTIFCATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	MORAINE

CRITERIA/INDICATORS:

Potential moraines, that are not indicated in the literature, were primarily located using airphoto interpretation techniques, substantiated by water well logs and field checks. These features were identified on the airphotos by studying the orientation of existing similar landforms as well as noting apparently anomalous topographic and tonal changes, as well as presence of sand and gravel pits.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Parts of the moraines contain variable subsoil conditions while other parts appear to have very little variability. This factor can be considered as a condition of concern rather than a constraint to siting. If potential sites are chosen within these morainal areas, then the first order of investigation should be to better define the nature of the landform in terms of its extent and geological composition (i.e. presence or absence of granular materials).

Certain inferences have been made about the location of some of these moraines, particularly in the case of possible buried features such as part of the Fort Erie Moraine, south of Hamilton.

A.1.5 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN FIELD

FACILITY COMPONENTS AFFECTED: All Facility Components.

DEFINITION OF FACTOR:

The extent of the drumlin field shows the approximate limits of an area which may contain buried drumlins consisting of granular Wentworth Till. Known locations of drumlins exposed at the surface also occur within this area.

RATIONALE/SIGNIFICANCE:

Should drumlins, especially if buried, or other areas of Wentworth Till exist in this area, they could provide possible pathways for off-site migration of contaminants in the ground water from a facility located in such an environment. The likelihood of sites located in this feature proving acceptable after detailed drilling studies is low.

SOURCES OF INFORMATION:

1980, 1:50,000 scale aerial photography, limited field checks and published geological literature as referenced. 1. Geologic and Hydrogeologic Inventory of the Golden Horseshoe Region. 2. Priority of Study of Zone 1 and 2 Lands - Golden Horseshoe - Geological Considerations. 3. Primary Environmental Information Geological/Hydrogeological Inventory Appendix Data Resource Sheets Vols. I and II.

INTERPRETATION/METHODOLOGY:

The boundary of the drumlin field is subjective and is based on some documentation of the existence of buried drumlins and inferences from known drumlin features, supported by a general identification of diagnostic pattern elements on the airphotos (i.e. linear patterns that indicate differences in internal soil drainage characteristics oriented in the same direction as known drumlins).

Most of the drumlin field area has been considered in previous phases of the study. A few small areas have been added where possible Wentworth Till drumlins exist that were previously not identified.

A.1.5 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN FIELD

CRITERIA/INDICATORS:

Linear orientation and characteristic elongated often oval shape of the drumlins as well as differences in internal soil drainage are the primary indicators used in delineating the extent of these areas.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The lines drawn to delineate the extent of the drumlin fields are subjective and are approximate at best. These areas are highlighted to act as cautionary zones for siting purposes .

A.1.6 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN (NIAGARA)

FACILITY COMPONENTS AFFECTED: All Facility Components.

DEFINITION OF FACTOR:

The drumlins are distinct elongated and often oval shaped hills that are readily identifiable on aerial photographs. They are diagnostic of past glacial ice movement and their long axes are aligned in a parallel direction to that movement. They often occur in groups forming what is known as a drumlin field.

RATIONALE/SIGNIFICANCE:

The drumlins in this area are composed of the granular Wentworth Till, which could provide pathways for off-site migration of contaminants in the ground water. Potential major impacts on the environment and major risks to human health could occur as a result of contaminant movement. This feature does not provide a second level of protection.

SOURCES OF INFORMATION:

1980, 1:50,000 scale aerial photography, limited field checks and published geological literature as referenced. 1. Geologic and Hydrogeologic Inventory of the Golden Horseshoe Region. 2. Priority of Study of Zone 1 and 2 Lands - Golden Horseshoe - Geological Considerations. 3. Primary Environmental Information Geological/Hydrogeological Inventory Appendix Data Resource Sheets Vols. I and II.

INTERPRETATION/METHODOLOGY:

Based on existing literature, these drumlins have been used to delineate precautionary geologic units in previous phases of the work. A small number of drumlins potentially consisting of Wentworth Till have been mapped, that previously were not identified in the literature. They were located through stereoscopic interpretation of aerial photographs combined with existing knowledge of the Quaternary history of these areas.

A.1.6 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	DRUMLIN (NIAGARA)

CRITERIA/INDICATORS:

Shape and orientation direction of long axis is diagnostic of these features, which were laid down beneath moving glaciers.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Not all drumlins, that have been mapped in addition to those identified in the Literature, have been field checked to affirm they are composed of Wentworth Till.

A.1.7 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	WETLAND

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR: Wetlands occur in depressional areas which may have high water table conditions and/or standing water for much of the year. They usually support the growth of wetland type plants and as a result of the decay and accumulation of plant material, organic soils probably have developed in these areas.

RATIONALE/SIGNIFICANCE:

These areas may require remedial drainage and/or excavation and filling for the construction of any facilities. Poor foundation materials, the presence of saturated soils or flooding conditions, and the possibility of movement of potential contaminants within the wetland area are the major items that may have to be considered for siting facilities.

These areas may also serve a natural function of regulating stream flow by helping to reduce flooding during periods of high run-off and augmenting stream flow during dry periods. Aside from losing this role, should they be used as a facilities site, they may have importance biologically in terms of aquatic and terrestrial wildlife as well as, vegetation associations. In some instances they may be used for watering of domestic animals and wildlife. This feature does not provide a second level of protection.

SOURCES OF INFORMATION:

- 1980, 1:50,000 scale airphotos and limited ground checking
- Agricultural Land-Use Information Systems
- 1:15,840 Ministry of Natural Resources Hazard Land Maps
- Wetland Mapping Services, Lands Directorate of Environment Canada.

INTERPRETATION/METHODOLOGY:

Although interpretation of airphotos was the primary method of identifying these areas, other available sources were researched and compiled onto the 1:50,000 base Terrain Conditions map.

For reasons cited above, these areas may present a variety of concerns for siting facilities. The wetlands are additional information that was not mapped in previous phases.

A.1.7 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	WETLAND

CRITERIA/INDICATORS:

Wetland type vegetation within a depressional area of very poor surface drainage that may have standing water and usually has an accumulation of organic materials. Shape of feature is usually irregular and area is not farmed. Consistent with the 1:50,000 map scale, features smaller than about 5 ha are not shown.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Depths and thicknesses of organic materials can be variable; however, lateral boundaries are fairly accurate but can be considered approximate in heavily treed areas. In some instances, the wetland areas may be intermixed with dry mineral soil areas.

A.1.8 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	SURFACE GRANULAR SOIL

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Surface granular soils include sands derived from a variety of sources and their thickness and relationship to both underlying and adjoining materials are largely unknown, but depths of greater than 1 m are probable.

RATIONALE/SIGNIFICANCE:

Surface granular soils are significant because they may provide ready pathways for off-site movement of contaminants in the ground water flow system. This could adversely affect both surface and ground water resources. Shallow wells may be developed in this surface granular soil and the potential for contamination of this shallow aquifer is high.

SOURCES OF INFORMATION:

- Physiography of Southern Ontario report (1966) and maps (1972)
- 1980, 1:50,000 airphotos and limited ground checking
- Ontario Geological Survey maps and reports
- Ontario Ministry of the Environment maps and reports
- Soil Survey Reports

INTERPRETATION/METHODOLOGY:

Initial identification (Phase I) was done using physiographic mapping (Chapman and Putnam 1966, 1972). At more detailed stages (Phase III) the Ontario Geological Survey and Ontario Ministry of the Environment maps were used. In the later stage of Phase III, air photo interpretation and a limited amount of field checking were employed. This sequence follows a progression from general identification to the notation of specific small-scale features.

In some instances, new information on surface granular soils have been added as a result of this stage of the work. An example occurs at Drumquin, about 4 km west of Streetsville.

A.1.8 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	SURFACE GRANULAR SOIL

CRITERIA/INDICATORS:

Clues as to the presence of sands are identifiable on airphotos by land use, soil drainage, topography and geologic landform conditions. Limited field checking verified their potential importance.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The boundaries of the surface granular soils are approximate because the depositional history of these soils has resulted in transitional boundary conditions. Thickness of this deposit is generally assumed to be greater than 1 m, but this may also vary.

A.1.9 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	FLOOD PLAIN

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

These areas are flat bottomlands adjacent to river or stream courses which may flood from time to time, especially during spring run-off or as a result of heavy prolonged storms.

RATIONALE/SIGNIFICANCE:

Inundation or damage caused by flooding of any of the facilities could result in the rapid release of contaminants into surface waters. To avoid flooding of the facility, fill would have to be placed and adequately protected. This might be possible in shallow water, low flow portions of the flood plain, provided the hydrology of the stream is not adversely constricted to the extent of affecting adjacent lands. Considerations of this nature would need to be addressed on a site specific basis. The alluvial soils of the flood plain are often granular textured and could allow easy off-site migration of contaminants. This feature does not provide a second level of protection.

SOURCES OF INFORMATION:

- 1980, 1:50,000 scale airphotos
- National Topographic Series, 1:50,000 base maps
- 1:15,840 scale, Ministry of Natural Resources Hazard Land Maps
- Conservation Authority's flood line maps, where available
- Official Plan documents.

INTERPRETATION/METHODOLOGY:

These areas have been outlined as a general indication of valley lands which may be prone to flooding and have not been dealt with in any previous stages of the work. They are plotted on the 1:50,000 scale Physical Resources maps.

Based upon the information that is available to date, these areas may present major concerns for siting of facilities.

A.1.9 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	FLOOD PLAIN

CRITERIA/INDICATORS:

Flood plains are generally flat land at or near the level of adjacent stream courses. These areas may show evidence of wet surface conditions or poor drainage, and are often identified by discrete topographic differences visible by stereoscopic interpretation of aerial photographs. In flat areas, where stream valleys are poorly defined, the distinction is not so easily made and other indicators such as differences in soil drainage and crop patterns are used to make judgements.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Accurate flood plain mapping requires a mathematical analysis of valley dimensions, run-off factors, historical statistical data etc. whereas, some of the flood plain areas identified here are from a three-dimensional interpretation of terrain features. This latter method gives a general indication of areas that are susceptible to flooding, and has been used in these areas where flood plain mapping is not available.

Although more extensive areas may result from the flood plain mapping technique, the two methods appear to be in general agreement, where flood plain mapping is available. Detailed flood plain mapping may be required for actual siting of facilities in areas where it is presently not available.

For this stage of the study, only the larger flood plains are shown that are mappable at the 1:50,000 scale.

A.1.10 - FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	STREAM COURSE

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

These streams represent the major tributaries to the main creeks and rivers. They have distinct valley forms as identified on 1:50,000 scale airphotos.

RATIONALE/SIGNIFICANCE:

Surface water courses provide an avenue for the rapid movement of potential contaminants, thus potentially affecting potable water supplies and aquatic life. Facilities located in stream course valleys may also be subject to structural damage by flooding. In some cases, relocation of the stream and/or providing engineered protective works may provide solutions for these concerns. This aspect would have to be considered on a site specific basis.

SOURCES OF INFORMATION:

- 1980, 1:50,000 scale airphotos
- National Topographic Series, 1:50,000 scale base maps
- 1:15,840 scale, Ministry of Natural Resources Hazard Land Maps

INTERPRETATION/METHODOLOGY:

Only major tributaries that have clearly defined valleys on the 1:50,000 airphotos have been noted. These are shown on the Terrain Conditions map and have not been dealt with in any previous stages of the work.

A.1.10- FACTORS USED IN IDENTIFICATION OF SITE AREAS

FACTOR GROUPING:	FACTOR:
PHYSICAL RESOURCES	STREAM COURSE

CRITERIA/INDICATORS:

Three-dimensional airphoto studies allow the delineation of established small valley systems and these locations can be pinpointed fairly accurately, even at this scale. Stream channels or swales, smaller than this size, are also evident and to a large extent represent the micro drainage network that do not have clearly defined flood zones at the 1:50,000 scale, and as such are not shown at this time.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The interpretation on stream courses is subjective and not based on hydrological data.

There are many more small stream channels or drains, and swales that have not been addressed at this phase of the work. These may be located on any given property, and will be delineated and evaluated regarding facilities development on a site specific basis, once site areas are defined.

A.2.1 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Natural Containment Potential

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Those geologic, hydrogeologic and physical terrain conditions which may influence the predictability of movement of contaminants in the subsurface are represented by a general "Natural Containment Potential" factor.

RATIONALE AND SIGNIFICANCE:

In keeping with OWMC's policy not to rely completely on engineered systems to safeguard the environment, all facilities are to be located where the natural environment contains predictable, uniform, geologic materials that will retard contaminant migration. Those hydrogeologic settings that are dominated primarily by thick, uniform, fine-textured soil materials appear to provide the desired degree of natural containment. Contaminant behaviour in such settings is reasonably predictable and the setting provides substantial lead time for implementing remedial measures in the event of an accidental spill or engineering failure. Emphasis is placed on establishing the uniformity, thickness and texture of the dominant geologic units underlying the site areas.

SOURCES OF INFORMATION:

The following sources of information were used:

- "Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Areas" draft report prepared by GLAL (1984);
- Constraint mapping undertaken during site area identification;
- Aerial photographs (1978, 1:10,000 scale; 1982 and 1983, 1:30,000 scale);
- Results of brief roadside visits to the site areas (field notes and colour photos taken in field).

INTERPRETATION/METHODOLOGY:

A summary table (Appendix C) was prepared on which information available for each site was included. Only readily available information was used, such as that provided in existing reports (Regional Category description, geologic predictability, aquifer(s) and that provided in the field notes (landforms, topography and drainage observations).

Individual site areas were compared and the sites were ranked qualitatively based on the anticipated level of natural containment provided by the hydrogeologic setting.

A.2.1 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Natural Containment Potential

CRITERIA/INDICATORS:

The hydrogeologic interpretation is based on the recognition that mappable (observed) geologic features are typically associated with assemblages of soil materials that have specific, physical properties. These properties influence contaminant movement in the subsurface and are therefore indicative of the natural containment provided by the geologic materials underlying a particular site. The following "indicators" of hydrogeologic conditions were used:

- Regional Categories;
- Geologic material texture (landform/topography and material texture)
- Geologic Predictability (stratigraphic complexities)

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Only readily available information was used. This information was often regional in nature and while it is suitable for a preliminary comparison of sites, detailed site work involving drilling would be required to verify the interpretation of subsurface conditions.

A.2.2 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Aquifer

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:
Aquifers are geologic units or formations which are sufficiently porous and permeable to be capable of supplying ground water to wells at a usable rate. Ground water is used extensively in rural areas as a source of water supply for domestic and agricultural purposes. The "aquifer" factor is defined as those aquifers which provide the principal sources of ground water supply in a given area.

RATIONALE/SIGNIFICANCE:
The protection of ground water quality for current and projected future uses is fundamental to the assessment of site suitability. Once ground water is contaminated, it is extremely difficult and expensive to institute an aquifer clean-up program and even then, the resource may be rendered unusable for tens if not hundreds of years.

Ground water is available for use in most areas of southern Ontario, although the value of the resource may vary significantly depending on the physical and chemical properties of the aquifer (water availability and quality), the uses of the resource and the availability of alternative water supplies.

The following "aquifers" (principal sources of ground water supplies), have been identified and are ranked below in order of their significance as sources of water supply.

- Granular deposits;
- Guelph/Amabel bedrock formations;
- Salina/Bass Island bedrock formations, and
- Queenston/Georgian Bay bedrock formations (granular materials at bedrock contact upper fractured portion of bedrock).

Although it may be desirable to avoid all areas underlain by major aquifers it should be recognized that even a marginal aquifer, such as the Queenston Formation, can represent a sole source of water for individuals in a specific area. Emphasis is therefore placed on the protection of all ground water resources through application of the "natural containment potential" factor. The aquifer factor was not applied during ranking of the site areas but was used instead to maintain a diversity of choice for future detailed candidate site investigations and subsequent comparisons.

SOURCES OF INFORMATION:

The following sources of information were used:

- Ground water resource reports and hydrogeologic mapping available from the Ontario Ministry of the Environment;
- "Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Areas" - draft report prepared by GLAL (1984).

A.2.2 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Aquifer

INTERPRETATION/METHODOLOGY:

The major aquifers were identified using only readily available information. This information was summarized in table format (Tables B1 and B2) but was not used in ranking the site areas.

CRITERIA/INDICATORS:

Information on the major aquifers can be readily obtained from water well records maintained on file with the Ontario Ministry of the Environment. Each record contains well construction details, a geologic log of the materials encountered during drilling and data on the depth at which water was found, relative well productivity and a general indication of water quality.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The ranking of aquifers provided herein based on the relative significance of the resource, is tentative. As noted the value of the aquifer is dependent primarily on the physical and chemical properties of the aquifer, the uses of the resource and the availability of alternative water supplies. It will therefore be necessary to collect additional information before finalizing the ranking. It is also conceivable that portions of 'marginal' aquifers, particularly where alternative water supplies are not available, are likely to assume greater significance as a source of supply than the aquifer in its entirety.

A.2.3 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Surface Drainage

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:
All surface drainage considerations which may affect facility siting are represented by a general "site area drainage" factor. This factor encompasses all drainage features (i.e. minor stream courses and associated flood plains and small wetland areas) which are not readily identifiable at the 1:50,000 scale used during constraint mapping).

RATIONALE/SIGNIFICANCE:
Location of facilities adjacent to or on stream courses and flood plains could result in inundation or damage by flooding of the facilities resulting in the rapid release of contaminants into surface water. Similarly, the alluvial soils of flood plains are commonly coarse textured and may provide a pathway for the rapid migration and dispersal of contaminants. Wetlands occur in depressional areas which may have high water table conditions and/or standing water much of the year. Organic soils are common to wetlands. These areas may require remedial drainage and/or excavation and filling to improve building foundation characteristics.

SOURCES OF INFORMATION:

The following sources of information were used:

- Aerial photographs (1978, 1:10,000 scale; 1982 and 1983, 1:30,000 scale), and
- Results of brief roadside visits to the site areas (field notes and colour photos taken in field).

INTERPRETATION/METHODOLOGY:
Flood plains, minor stream courses and wetland areas were identified using airphotos and the extent of these features outlined on 1:10,000 scale site area maps. The presence of these features was verified in the field.

Flood plains and perennial stream courses were treated as exclusionary and were used to modify site area boundaries and to establish site area size adequacy based on facility positioning. Wetlands and intermittant stream courses are identified as potential minor constraints, the significance of which would need to be established on a site by site basis.

A.2.3 - FACTORS FOR IDENTIFICATION OF POTENTIAL SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Surface Drainage

CRITERIA/INDICATORS:

The physical characteristics of the individual drainage features which facilitate their ready identification during stereoscopic interpretation of aerial photographs are described in the factor sheets used for site area identification. The work undertaken during site area screening represented a 1:10,000 scale refinement of the earlier work.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The interpretation on stream courses is subjective and not based on hydrogeologic date.

Accurate flood plain mapping requires a mathematical analysis of topographic relief, run-off factors, historical statistical data etc. whereas, the flood plains identified here are from an interpretation of terrain features identified on aerial photographs. This method gives a general indication of areas that are susceptible to flooding.

Although more extensive areas may result from the flood plain mapping technique, the two methods appear to be in general agreement, where flood plain mapping is available. Detailed flood plain mapping may be required for actual siting of facilities in areas where it is presently not available.

Depths and thicknesses of organic materials in wetland depressions are variable. Lateral boundaries are however, fairly accurate but can be considered approximate in heavily treed areas. In some instances, the wetland areas may be intermixed with dry mineral soil areas.

A.3.1 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Natural Containment Potential

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Those geologic, hydrogeologic and physical terrain conditions which may influence the predictability of movement of contaminants in the subsurface are represented by a general "Natural Containment Potential" factor.

This same factor was used during site area screening. During the initial comparative evaluation, additional information of a site specific nature was collected to refine the data base developed during site areas screening.

RATIONALE AND SIGNIFICANCE:

In keeping with OWMC's policy not to rely completely on engineered systems to safeguard the environment, all facilities are to be located where the natural environment contains predictable, uniform, geologic materials that will retard contaminant migration. Those hydrogeologic settings that are dominated primarily by thick, uniform, fine-textured soil materials appear to provide the desired degree of natural containment. Contaminant behaviour in such settings is reasonably predictable and the setting provides substantial lead time for implementing remedial measures in the event of an accidental spill or engineering failure. Emphasis is placed on establishing the uniformity, thickness and texture of the dominant geologic units underlying the site areas.

SOURCES OF INFORMATION:

The following sources of information were used:

- "Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Areas" draft report prepared by GLAL (1984);
- site area assessments (field notes and maps);
- aerial photographs (1978, 1:10,000 scale; 1982 and 1983, 1:30,000 scale);
- geologic logs for water wells (computer printout of well records on file with the Ontario Ministry of the Environment - current to December 1980).

INTERPRETATION/METHODOLOGY:

All previously collected information which may have some bearing on the geology and hydrogeology of the potential sites, was re-examined.

A description of the geologic and hydrogeologic setting of each site was completed (Appendix D) and the individual sites were compared and rated qualitatively based on the perceived level of natural containment provided by the setting.

A.3.1 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Natural Containment Potential

CRITERIA/INDICATORS:

The hydrogeologic interpretation is based on the recognition that mappable (observed) geologic features are typically associated with assemblages of soil materials that have specific, physical properties. These properties influence contaminant movement in the subsurface and are therefore indicative of the natural containment provided by the geologic materials underlying a particular site. The following "indicators" of hydrogeologic conditions were used:

- Regional categories;
- Oil and Gas Wells
- Confining layer thickness;
- Geologic material texture (landform/topography and material texture);
- Geologic Predictability (stratigraphic complexities).

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Only readily available information was used. This information was often regional in nature and while it is suitable for a preliminary comparison of sites, detailed site work involving drilling would be required to verify the interpretation of subsurface conditions.

A.3.2 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Aquifer

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

Aquifers are geologic units or formations which are sufficiently porous and permeable to be capable of supplying ground water to wells at a usable rate. Ground water is used extensively in rural areas as a source of water supply for domestic and agricultural purposes. The "aquifer" factor is defined as those aquifers which provide the principal sources of ground water supply in a given area. This same factor was used during site area screening.

RATIONALE/SIGNIFICANCE:

The protection of ground water quality for current and projected future uses is fundamental to the assessment of site suitability. Once ground water is contaminated, it is extremely difficult and expensive to institute an aquifer clean-up program and even then, the resource may be rendered unusable for tens if not hundreds of years.

Ground water is available for use in most areas of southern Ontario, although the value of the resource may vary significantly depending on the physical and chemical properties of the aquifer (water availability and quality), the uses of the resource and the availability of alternative water supplies.

The following "aquifers" (principal sources of ground water supplies), have been identified and are ranked below in order of their significance as sources of water supply.

- Granular deposits;
- Guelph/Amabel bedrock formations;
- Salina/Bass Island bedrock formations, and
- Queenston/Georgian Bay bedrock formations (granular materials at bedrock contact upper fractured portion of bedrock).

Although it may be desirable to avoid all areas underlain by major aquifers it should be recognized that even a marginal aquifer, such as the Queenston Formation, can represent a sole source of water for individuals in a specific area. Emphasis is therefore placed on theprotection of all ground water resources through application of the "natural containment potential" factor. The aquifer factor was not applied during ranking of the potential sites but was used instead to maintain a diversity of choice for future detailed candidate site investigations and subsequent comparisons.

SOURCES OF INFORMATION:

The following sources of information were used:

- Ground water resource reports and hydrogeologic mapping available from the Ontario Ministry of the Environment;
- "Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Areas" - draft report prepared by GLAL (1984)
- Geologic logs for water wells (computer printout of well records on file with the Ontario Ministry of the Environment - current to December 1980).

A.3.2 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Aquifer

INTERPRETATION/METHODOLOGY:

The major aquifers were identified using only readily available information. This information was summarized in table format (Table 12) but was not used in ranking the potential sites.

CRITERIA/INDICATORS:

Information on the major aquifers can be readily obtained from water well records maintained on file with the Ontario Ministry of the Environment. Each record contains well construction details, a geologic log of the materials encountered during drilling and data on the depth at which water was found, relative well productivity and a general indication of water quality.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

The ranking of aquifers provided herein based on the relative significance of the resource, is tentative. As noted the value of the aquifer is dependent primarily on the physical and chemical properties of the aquifer, the uses of the resource and the availability of alternative water supplies. It will therefore be necessary to collect additional information before finalizing the ranking. It is also conceivable that portions of 'marginal' aquifers, particularly where alternative water supplies are not available, are likely to assume greater significance as a source of supply than the aquifer in its entirety.

A.3.3 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Surface Drainage

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR:

All surface drainage considerations which may affect facility siting are represented by a "surface drainage" factor. This factor encompasses site-specific drainage considerations such as surface drainage efficiency, potential drainage constraints and ease of implementing surface drainage controls if required.

RATIONALE/SIGNIFICANCE:

Site design and operation is influenced to some extent by the surface drainage characteristics of the site. Although engineering and operational measures are available to mitigate most concerns related to drainage deficiencies, these measures can add to the overall development and operational costs. In keeping with OWMC's goal to minimize financial costs, it is therefore important to anticipate what site drainage improvements may be required.

SOURCES OF INFORMATION:

The following sources of information were used:

- Aerial photographs (1978, 1:10,000 scale; 1982 and 1983, 1:30,000 scale);
- Results of brief roadside visits to the potential sites (field notes and colour photos taken in field and
- flood plain mapping where available.

CRITERIA/INDICATORS:

The following indicators were used in evaluation of the potential sites:

Topographic Relief: refers to the general slope of the site. Good surface drainage requires sufficient relief or slope to provide positive, efficient drainage. Relatively flat sites tend to be less well drained and to dry out more slowly (all other factors being equal). Moderate relief is preferred to provide efficient surface drainage without significant erosion.

On-Site Surface Drainage: describes the path which storm water takes to drain through the site and includes the overland flow path, together with swales and channels where flow is concentrated. Good drainage is characterized by an efficient, well developed, continuous network of swales and channels, draining all parts of the site. By contrast, surface depressions, with no apparent outlet, may remain wet for extended periods of time.

Upstream Drainage Area: related to the potential quantity of water from upstream which has to be handled via watercourses passing through the site. Large upstream drainage areas are generally indicative of greater volumes of runoff and larger conveyance requirements, which may restrict siting of facilities.

A.3.3 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES

FACTOR GROUPING:	FACTOR:
Physical Resources	Surface Drainage

CRITERIA/INDICATORS (cont'd)

Susceptibility to Flooding: generally refers to the low lying areas adjacent to watercourses which flood periodically during spring melt and/or during periods of heavy, sustained rainfall. When large volumes of water are required to be handled, the potential for flooding normally increases and the conveyance systems may represent significant constraints to siting of facilities. Backup of flood water from off-site is also considered.

Surface depressions, with no outlet or which are inefficiently drained, while not generally subject to significant flooding, may adversely affect site operations and require correction.

Availability of Outlet: refers to the capability of watercourses and conveyance structures, both on-site and off-site, to conduct runoff away from the site. Inadequate outlets will require upgrading to mitigate adverse impacts.

Drainage Sheds: relates to the potential for migration of contaminated runoff from the site. In the event of accidental contamination of surface runoff, confinement of the pollutants to a single watercourse (drainage shed) is preferred rather than spreading to multiple receiving bodies.

COMMENTS/ASSUMPTIONS/LIMITATIONS:

No on-site investigations or other detailed analytical work was undertaken at this stage. Further work will be required on the candidate sites to more accurately establish flood susceptible areas and to define the required scope of on-site and/or off-site drainage works.

A.4 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES (Access Routes)

FACTOR GROUPING:	FACTOR:
Physical Resources	Sensitive Lands

FACILITY COMPONENTS AFFECTED: All Facility Components

DEFINITION OF FACTOR: All hydrogeologic considerations which may affect the selection of an access route are represented by a general "sensitive lands" factor. Certain near-surface geologic/hydrogeologic settings do not provide containment of contaminants in the event of an accidental spill.

RATIONALE/SIGNIFICANCE: In the event of an accidental spill of wastes, it is important that the natural materials retard the migration of waste contaminants from the area of the spill through the subsurface. This retardation provides sufficient lead time to implement remedial actions. Lands underlain by fine textured soils provide the desired degree of natural containment. Contaminant movement is potentially rapid through granular materials and bedrock. Lands where such materials are either at or near surface are not likely to provide the desired degree of natural containment. These lands were defined as "sensitive".

SOURCES OF INFORMATION: The following sources of information were used:

- published surficial geology maps;
- physical resource constraint mapping

INTERPRETATION/METHODOLOGY: Alternative access routes were provided by OWMC on 1:50,000 scale topographic map bases. Those segments of the alternative access routes (both local and regional roads) underlain by "sensitive" lands were identified.

The actual linear distance that the access routes cross over these sensitive route segments was calculated. This information was tabulated and provided to OWMC.

A.4 - FACTORS FOR IDENTIFICATION OF CANDIDATE SITES (Access Routes)

FACTOR GROUPING:	FACTOR:
Physical Resources	Sensitive Lands

CRITERIA/INDICATORS: Indicators of sensitive lands include those underlain by:

- bedrock at or near surface;
- granular soil at or near surface;
- floodplain deposits (generally variable texture);
- man-made fill (such as excavate material from the Welland Canal - generally variable texture).

COMMENTS/ASSUMPTIONS/LIMITATIONS:

Only readily available published information and that collected during constraint mapping was used. The published information is presented at a 1:50,000 scale. Local conditions may vary from that presented in the mapping.

It should be noted that an emergency response spill clean-up team will likely be established as part of facility operations. As such any spills that may occur will be decommissioned immediately. Consequently, the access route physical resource factor is not a major consideration in overall access route ranking or site ranking.

APPENDIX B

IDENTIFICATION OF POTENTIAL SITES

APPENDIX B - IDENTIFICATION OF POTENTIAL SITES

CONTENTS

FIGURES		PAGE
B-1	FIELD OBSERVATION SUMMARY - GEOLOGY	B-1
B-2	FIELD OBSERVATION SHEET - GEOLOGICAL STATIONS	B-3
B-3	PHYSICAL RESOURCE FEATURES - LF-4 WEST	B-5
TABLES		
B-1	SUMMARY OF SITE AREA CHARACTERISTICS AND RANKING (LANDFILL/INTEGRATED FACILITIES)	B-6
B-2	SUMMARY OF SITE AREA CHARACTERISTICS AND RANKING (PHYSICAL/CHEMICAL TREATMENT AND INCINERATOR FACILITIES)	B-8

FIGURE B-1

Field Observation Summary - Geology

Gartner Lee Associates Limited

Project 83-S19 **Client** OWMC

Date Dec 6/83 **Weather** drizzle, foggy, cool.

Time & Duration 1:30 - 3:00 pm **Ground Condition** snow patches

Observer(s) D. McQuay **Location** LF-4W

Purpose To conduct reconnaissance survey for verification of existing terrain/geology information base

Topography gently rolling to level

Surface Drainage intermittent, drainage swales mainly through cultivated fields; main swale flowing north-south through centre of site has fluid flow up to about 15m wide (many) because of low relief this swale could probably be re-located as required, particularly towards south

Landform(s) • lacustrine silt and clay cap over clay till; till exposed at surface in places
• possible buried meander belt in northern boundary of site area

V Ch 10/02/84

Materials clayey silt to silty clay, few stones, laminated to blocky structure

Comments entire site area is in active agricultural use (cropped) except for occasional homes around periphery + hamlet of Binbrook

Conclusions • physical aspects of site are in apparent agreement with existing resource base
• drainage swale north-south through center of site represents additional information and has narrow flood prone zone with intermittent flow, which would need to be addressed in location of facility and/or possible re-location of swale

Sketch • site may be partially affected in northern area based on presence of possible buried moraine, otherwise boundaries are unaffected as per existing terrain/geology information base.

Field Observation Sheet - Geological Stations

Gartner Lee Associates Limited

Page 1 of 1

Site Area LF-4W Date Dec 6/83

Observer D. McQuay

Station 1 (Roll ___ ; Photo ___)

rd. cut 2m+, silty clay till, brown, stiff, sloping slong contours along the site, runs in low trib. cap towards north. • gently rolling to level • small cultivated drainage 3 - 3.5m avail.

Station 2 (Roll 1 ; Photo 13 & 14) 13 to east 14 to west

drainage is small flow, full width depth ± 1m, cultivated to edge, small flood plain 30 to ± 40m wide, probably intermittent

Station 3 (Roll 1 ; Photo 15) - to north

• gently rolling farm land

• Silty clays in ditches

Station 4 (Roll 1 ; Photo 16) to west

Stream course ± 10m wide through 1.5m culvert. flood plain upto ± 60 m wide.

Station 5 (Roll 1 ; Photo 17 & 18) 17 to S. 18 to north

Stream valley, channel, valley ± 50m wide, channel less than 5m wide to south

• Silt-clays in ditches

Station 6 (Roll ___ ; Photo ___)

intermittent grassed drainage swale ± 2m wide, floor width ± 10m

• Silt-clay in ditches

Station 7 (Roll —; Photo —)

Small drainage swale ± 1m wide through cultivated farm fields, intermittent.
Silt-clay in ditches.

Station 8 (Roll —; Photo —)

Small drainage swale, intermittent through farm fields, ± 2m wide, relief ≤ 3m, flood zone potentially, about 15m wide to town (south).
• Silty clays in ditches.

Station 9 (Roll ____; Photo ____)

Station 10 (Roll ____; Photo ____)

Comments

OWMC Ontario Waste Management Corporation

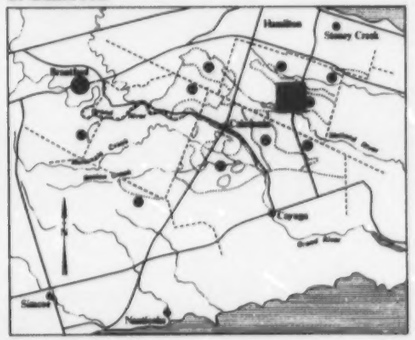
Consultant:
Gartner Lee Associates Limited

Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

not to scale
MAXIMUM POTENTIAL ACQUISITION BOUNDARY — 400m STUDY AREA

Key Map: **LF-4 West**
Lots 3,4,5; Concession IV (Block 4); Township of Glanbrook, formerly Township of Binbrook



1000 feet — 1000
500 metres — 500

Physical Resource Features
POTENTIAL SITE IDENTIFICATION

October 1984 **FIGURE B3**

Table B-1
Summary Of Site Area Characteristics & Ranking (LANDFILL/INTEGRATED FACILITIES)

Site Area	Natural Containment Potential													Aquifer				Surface Drainage		
	Regional Category (Confining Layer Thickness)					Geologic Material(s)				Geologic Uniformity										
	1A (>30 m)	1B (20-30 m)	1C (10-20 m)	2A (20-30 m)	2B (10-20 m)	Lacustrine silt-clay	Halton Till	Mixed (moraine)	Spoil	Uniform Geology	Moderate Variability	Variable Geology	Ranking	Saling-Bass Island Formations	Queenston-Georgian Bay Formations	Guelph-Amabel Formations	Granular Materials	No Drainage Constraints	Minor Drainage Constraints	Major Drainage Constraints
LF-1A1				x			x				x		Level 3				x		x	
LF-2A1				x			x				x		Level 3				x			x
LF-1B		x					x			x			Level 2		x		x		x	
LF-2B				x			x	x			x	x	Level 3		x		x		x	
LF-3B				x			x	x			x	x	Level 3		x		x			x
LF-4B		x					x			x			Level 2		x		x		x	
LF-2W*				x	x	x					x		Level 3	x						x
LF-3W*		x			x	x					x		Level 3			x				x
LF-4W		x				x				x			Level 2			x				x
LF-5W				x		x					x		Level 3			x				x
LF-7W		x				x				x			Level 2			x				x
LF-10W				x		x					x		Level 3			x	x			x
LF-11W				x		x					x		Level 3			x	x			x
LF-13W				x		x					x		Level 3	x					x	
LF-14W				x		x					x		Level 3	x		x	x			x
LF-1C	x					x				x			Level 1	x					x	
LF-2C	x					x				x			Level 1	x					x	
LF-3C	x	x				x				x			Level 2	x					x	
LF-8C	x					x				x			Level 1			x			x	
LF-9C	x					x				x			Level 1			x				x
LF-12C		x				x				x			Level 2			x			x	
LF-13C*		x			x	x					x		Level 3			x			x	
LF-15C	x					x				x			Level 1	x					x	
LF-18C	x					x				x			Level 1	x		x				x
LF-24C		x				x				x			Level 2			x			x	
LF-25C	x	x				x				x			Level 2			x			x	
LF-29C	x					x				x			Level 1	x		x				x
LF-30C	x					x				x			Level 1	x		x				x

*Portion of site area may contain less than 20 m of fine-textured soil

P.A. = POTENTIALLY ACCEPTABLE

Gartner Lee Associates Limited

Table B-1

Summary Of Site Area Characteristics & Ranking (LANDFILL/INTEGRATED FACILITIES)

Site Area	Natural Containment Potential													Aquifer				Surface Drainage		
	Regional Category (Confining Layer Thickness)					Geologic Material(s)				Geologic Uniformity										
	1A (>30 m)	1B (20-30 m)	1C (10-20 m)	2A (20-30 m)	2B (10-20 m)	Lacustrine silt-clay	Halton Till	Mixed (morraine)	Spoil	Uniform Geology	Moderate Variability	Variable Geology	Ranking	Saline-Bass Island Formations	Queenston-Georgian Bay Formations	Guelph-Amabel Formations	Granular Materials	No Drainage Constraints	Minor Drainage Constraints	Major Drainage Constraints
LF-1E		x				x				x			Level 2	x						x
LF-2E	x					x			x	x		x	Level 1	x					x	
LF-3E		x				x				x			Level 2	x		x				x
LF-4E		x				x				x			Level 2			x			x	
LF-5E	x					x			x	x		x	Level 1	x					x	
LF-7E	x					x			x	x		x	Level 1	x						x
LF-8E	x					x			x	x		x	Level 1	x						x
LF-9E		x				x				x			Level 2	x						x
LF-10E		x				x				x			Level 2	x		x				x
LF-12E		x				x				x			Level 2	x						x

Gartner Lee Associates Limited

Table B-2

Summary Of Site Area Characteristics & Ranking (PHYSICAL/CHEMICAL TREATMENT AND INCINERATOR FACILITIES)

SITE AREA	NATURAL CONTAINMENT POTENTIAL													AQUIFER				SURFACE DRAINAGE		
	REGIONAL CATEGORY (CONFINING LAYER THICKNESS)					GEOLOGIC MATERIAL(S)				GEOLOGIC UNIFORMITY										
	1A (>30 m)	1B (20-30 m)	1C (10-20 m)	2A (20-30 m)	2B (10-20 m)	Lacustrine silt-clay	Halton Till	Mixed (moraine)	Spoil	Uniform Geology	Moderate Variability	Variable Geology	Ranking	Salina-Bass Island Formations	Queenston-Georgian Bay Formations	Guelph-Amabel Formations	Granular Materials	No Drainage Constraints	Minor Drainage Constraints	Major Drainage Constraints
PI-1A1				x			x				x		Level 3				x		x	
PI-2B1				x			x				x		Level 3				x			x
PI-3A1				x			x				x		Level 3							x
PI-1B		x					x			x			Level 1		x		x	x		
PI-2B			x				x			x			Level 2		x		x		x	
PI-3B				x			x	x			x	x	Level 3		x		x			x
PI-4B				x			x	x			x	x	Level 3		x		x		x	
PI-5B				x			x	x			x	x	Level 3		x		x			x
PI-6B				x			x				x		Level 3		x		x			x
PI-10B			x				x			x			Level 2		x		x			x
PI-11B			x				x			x			Level 2		x		x			x
PI-12B			x				x			x			Level 2		x		x		x	
PI-13B			x				x			x			Level 2		x		x		x	
PI-14B			x				x			x			Level 3		x		x			x
PI-15B			x				x			x			Level 2		x		x		x	
PI-2W				x		x					x		Level 3			x	x			x
PI-1C			x			x				x			Level 2			x			x	
PI-2C		x			x	x					x		Level 3			x			x	
PI-11C	x	x								x			Level 1			x			x	
PI-15C	x		x			x							Level 2	x					x	
PI-19C		x			x	x				x	x		Level 3			x				x
PI-21C		x				x				x			Level 1			x			x	
PI-22C			x			x				x			Level 2			x			x	
PI-25C	x					x				x			Level 1	x		x				x
PI-26C	x	x				x				x			Level 1	x					x	

Gartner Lee Associates Limited

Table B-2

Summary Of Site Area Characteristics & Ranking (PHYSICAL/CHEMICAL TREATMENT AND INCINERATOR FACILITIES)

Site Area	NATURAL CONTAINMENT POTENTIAL													AQUIFER				SURFACE DRAINAGE		
	REGIONAL CATEGORY (CONFINING LAYER THICKNESS)					GEOLOGIC MATERIAL(S)				GEOLOGIC UNIFORMITY										
	1A (>30 m)	1B (20-30 m)	1C (10-20 m)	2A (20-30 m)	2B (10-20 m)	Lacustrine silt-clay	Halton Till	Mixed (moraine)	Spoil	Uniform Geology	Moderate Variability	Variable Geology	Ranking	Salina-Bass Island Formations	Queenston-Georgian Bay Formations	Guelph-Amabel Formations	Granular Materials	No Drainage Constraints	Minor Drainage Constraints	Major Drainage Constraints
*PI-1E			x			x			x	x		x	Level 2	x		x			x	
PI-2E			x			x			x	x		x	Level 2	x		x			x	
PI-3E			x			x			x	x		x	Level 2	x		x			x	
PI-4E			x			x				x			Level 2	x		x				x
PI-5E			x			x				x			Level 2	x					x	
PI-6E		x				x				x			Level 1	x		x				x
PI-7E			x			x				x			Level 2	x		x			x	
PI-8E			x			x				x			Level 2	x		x				x
PI-9E			x			x				x			Level 2	x					x	
PI-10E			x			x				x			Level 2	x					x	
PI-11E			x			x				x			Level 2	x					x	
PI-12E			x			x				x			Level 2	x						x
PI-13E			x			x				x			Level 2	x					x	
PI-14E*			x			x				x			Level 2	x						x
PI-15E			x			x				x			Level 2	x						x
PI-16E			x			x				x			Level 2					x		
PI-17E**	x					x		x		x		x	Level 1					x		
PI-18E**	x					x				x		x	Level 1						x	
PI-19E**	x					x		x	x	x		x	Level 1						x	
PI-20E			x			x				x			Level 2	x				x		
PI-21E	x					x			x	x		x	Level 1	x					x	
PI-26E		x				x		x		x		x	Level 1	x						x
PI-27E		x				x				x			Level 1	x		x				x
PI-30E		x				x				x			Level 1	x		x				x
PI-31E			x			x				x			Level 2	x						x
PI-34E	x					x			x	x		x	Level 1	x					x	
PI-37E		x				x				x			Level 1	x						x

* portion of site area on Category 4 lands.

** portion of site area on Category 3 lands.

Gartner Lee Associates Limited

APPENDIX C

IDENTIFICATION OF CANDIDATE SITES -

SUMMARY DESCRIPTIONS OF THE GEOLOGY AND HYDROGEOLOGY OF THE POTENTIAL SITES

APPENDIX C IDENTIFICATION OF CANDIDATE SITES - SUMMARY DESCRIPTIONS OF THE GEOLOGY AND HYDROGEOLOGY OF THE POTENTIAL SITES

CONTENTS

		PAGE
C.1	INTRODUCTION	C - 1
C.2	SITE LF-2N	C - 1
C.3	SITE LF-4N	C - 4
C.4	SITE PI-1A1	C - 6
C.5	SITE PI-1N	C - 8
C.6	SITE PI-13N	C - 10
C.7	SITE LF-10W	C - 12
C.8	SITE LF-11W	C - 15
C.9	SITE PI-2W	C - 17
C.10	SITE LF-1C	C - 19
C.11	SITE LF-3C	C - 21
C.12	SITE LF-8C	C - 23
C.13	SITE LF-9C	C - 26
C.14	SITE LF-1E	C - 29
C.15	SITE LF-3E	C - 33
C.16	SITE PI-18E	C - 36
C.17	SITE PI-27E	C - 39

CONTENTS (CONT'D)

FIGURE		PAGE
C-1	Physical Resource Features - LF-2 North	C - 3
C-2	Physical Resource Features - LF-4 North	C - 5
C-3	Physical Resource Features - PI-1A1	C - 7
C-4	Physical Resource Features - PI-1 North	C - 9
C-5	Physical Resource Features - PI-13 North	C - 11
C-6	Physical Resource Features - LF-10a West	C - 13
C-7	Physical Resource Features - LF-10b West	C - 14
C-8	Physical Resource Features - LF-11 West	C - 16
C-9	Physical Resource Features - PI-2 West	C - 18
C-10	Physical Resource Features - LF-1 Central	C - 20
C-11	Physical Resource Features - LF-3 Central	C - 22
C-12	Physical Resource Features - LF-8 Central	C - 25
C-13	Physical Resource Features - LF-9 Central	C - 28
C-14	Physical Resource Features - LF-1a East	C - 31
C-15	Physical Resource Features - LF-1b East	C - 32
C-16	Physical Resource Features - LF-3 East	C - 35
C-17	Physical Resource Features - PI-18 East	C - 38
C-18	Physical Resource Features - PI-27 East	C - 41

APPENDIX C

SUMMARY DESCRIPTIONS OF THE GEOLOGY AND HYDROGEOLOGY OF THE POTENTIAL SITES

C.1 INTRODUCTION

The following descriptions are summaries of the information gathered pertaining to the 16 potential candidate sites up to and including the initial comparative evaluation. The descriptions are based largely on Phase 3A and early 3B activities, (Geologic and Hydrogeologic Inventory of the Golden Horseshoe Candidate Region, Gartner Lee Associates Limited, 1984, constraint mapping and site reconnaissance visits). The literature references used in these earlier studies have not been repeated in this appendix and the reader is referred to these studies for a literature survey and bibliography.

It should be noted that some of the conditions identified in this discussion, particularly those pertaining to subsurface variability, are geologic inferences. At this time, they are identified only as potential concerns based on available information. Future, more detailed, studies could readily resolve these potential concerns and they should not be considered as particularly negative influences until this further work has been completed.

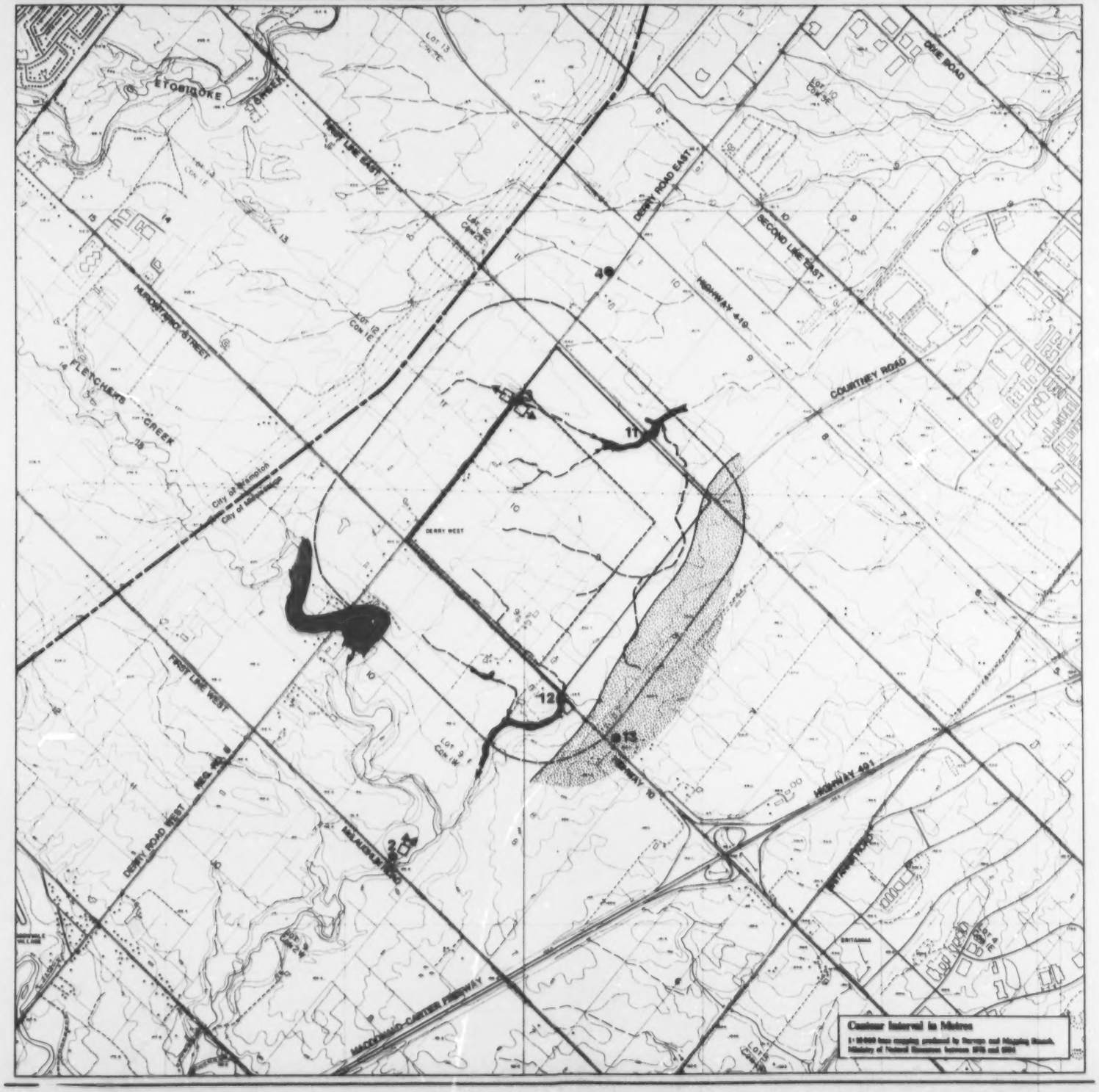
C.2 SITE LF-2N

Site LF-2N is located on the northeast side of Highway 10 approximately two km north of Highway 401 and approximately

seven km south of Brampton. The site is located on a rolling to gently rolling portion of the Halton Till Plain.

The Quaternary geology of the Brampton area has not been mapped in detail. Our knowledge of the area is derived from scattered detailed references in the area, detailed work in adjoining areas, and generalized regional mapping. These data sources are expected to yield a fairly accurate impression of the materials in the area. The main material in the area is the Halton clayey silt to silt till. This unit is known to contain several subunits which may exhibit slight differences in physical properties. Inclusions of lenses of granular material and large amounts of shale are well known within the till and the till is known to overlie sand materials in the general Brampton area. An intermittent surface veneer of sand, silt and clay may be present locally. The till is commonly 10 to 15 m thick, but may be thicker in bedrock depressions such as that believed to exist beneath site LF-2N. Several silt to sandy silt till units, combined with stratified sand, silt and clay materials have been documented beneath the Halton Till to the east of site LF-2N (in the Toronto area) but it is not known if these materials are present at the site.

There are approximately a dozen wells on or very close to the site and another dozen within one km of the site. Coverage is sparse on the northeast side of the site. The wells suggest a range of "clay" thicknesses ranging from 10 to 34 m. About three quarters of the wells note sand lenses in their logs or terminate within the till sequence above bedrock. In many cases these sand seams yield domestic water supplies. Some of the deeper wells obtain water from the red shale of the



OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

Legend:

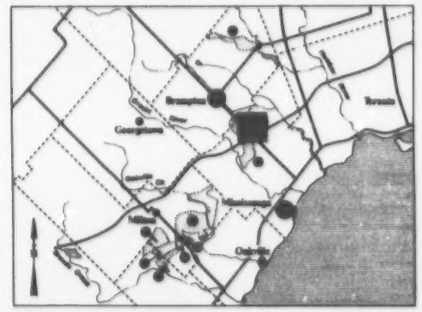
- Till Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

LIMIT OF LANDFILL (approx.) — not to scale

MAXIMUM POTENTIAL ACQUISITION BOUNDARY — 500 metres — STUDY AREA

Key Map: **LF-2 North**

Lots 9 and 10; Concession I EHS (East of Hurontario Street), City of Mississauga



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 Feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-1**

Queenston Formation. The grey shale of the Georgian Bay Formation is present on the northeast edge of the site. Recent terrain analysis of the area has located a morainic feature immediately south of the site.

C.3 SITE LF-4N

Site LF-4N is located on the Halton Till Plain approximately 5 km south of the town of Milton. The land is gently rolling and contains occasional poorly drained depressions.

Regionally the Halton Till, which is exposed at surface on the site, is known to contain several subunits which contain slightly different physical characterisitcs, and inclusions of granular materials. An intermittent surface veneer of sand, silt or clay may be present locally. The Halton Till in the area is a clayey silt till and is known to be up to 24 m in thickness. A silt to sandy silt till has also been encountered at depth, beneath the Halton Till. A detailed well survey in the area indicates approximately a dozen wells on and adjacent to the site. Several wells indicate sand lenses in the till and some houses obtain water from these sources. Subsurface hydrogeologic testing conducted in the area indicates a range of 15-24 m thicknesses of Halton Till are present within a buried bedrock valley cut into the red shale of the Queenston Formation. The detailed drilling indicated relatively few sand lenses within the till but did encounter water bearing sand beneath the two tills in the bottom of the buried bedrock valley. It is known that sand and gravel comprises a significant portion of the valley fill in the upper portion of the valley, near the Niagara Escarpment.

OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

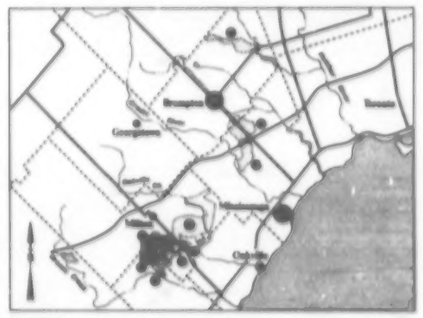
Legend:

- Till Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

TOWN OF MILTON — MAXIMUM POTENTIAL ACQUISITION BOUNDARY

Key Map: **LF - 4 North**

Lots 6 and 7; Concession VII; Town of Milton, formerly in the Township of Nelson



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

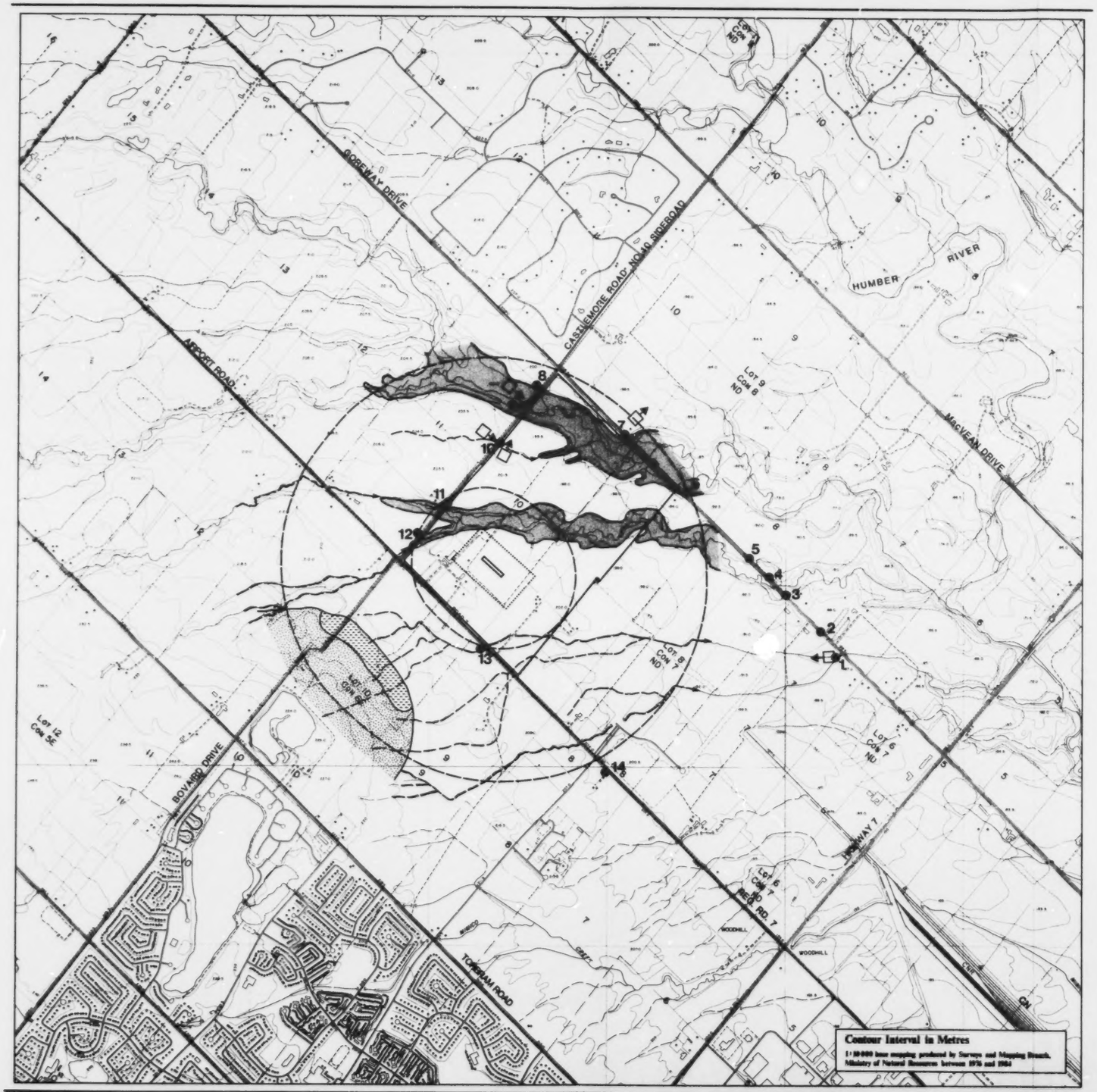
Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-2**

C.4 SITE PI-1A1

Site PI-1A1 is located several km northeast of Bramalea on a gently rolling portion of the Halton Till Plain.

The major surface till unit in the area is the Halton silt to clayey silt till. Locally this unit may be overlain by several m of the Wildfield silt-clay till-lacustrine complex. The Halton Till is known to contain several subunits with slightly differing physical properties. It also contains lenses of granular materials and may contain local concentrations of shale bedrock. The Halton Till is locally known to directly overlie shale bedrock, overlie silty sand materials and/or an older sandy silt till. The regional water well data indicate that site PI-1A1 overlies a buried bedrock valley which is cut into the shales of the Georgian Bay Formation. Water wells indicate that much of the valley contains till. The till is between 21-38 m in thickness at the site and approximately a dozen wells close to the site indicate both sand lenses within the till at various depths and a body of sand beneath the till, resting on bedrock. Wells are supplied by sand lenses within and below the till and from the shale bedrock. A zone of buried granular materials (moraine) which has previously been mined for aggregate, is known to exist immediately southwest of the site. This material is partially buried by Halton Till and is typical of many similar occurrences in the region. It is not known what connection, if any, this buried granular has to either the sand lenses within the till or with the basal sand aquifer within the bedrock valley. The northeastern edge of the bedrock valley is estimated to occur close to but just outside the site boundary.



OWMC Ontario Waste Management Corporation

Consultant:

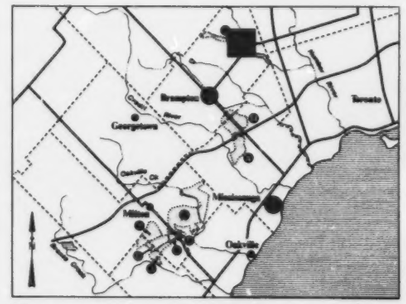
Gartner Lee Associates Limited

Legend:

- Till Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

Key Map: **PI-1A1**

Lot 10 and Part of Lot 9; Concession VII; City of Brampton, formerly the Toronto Gore



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

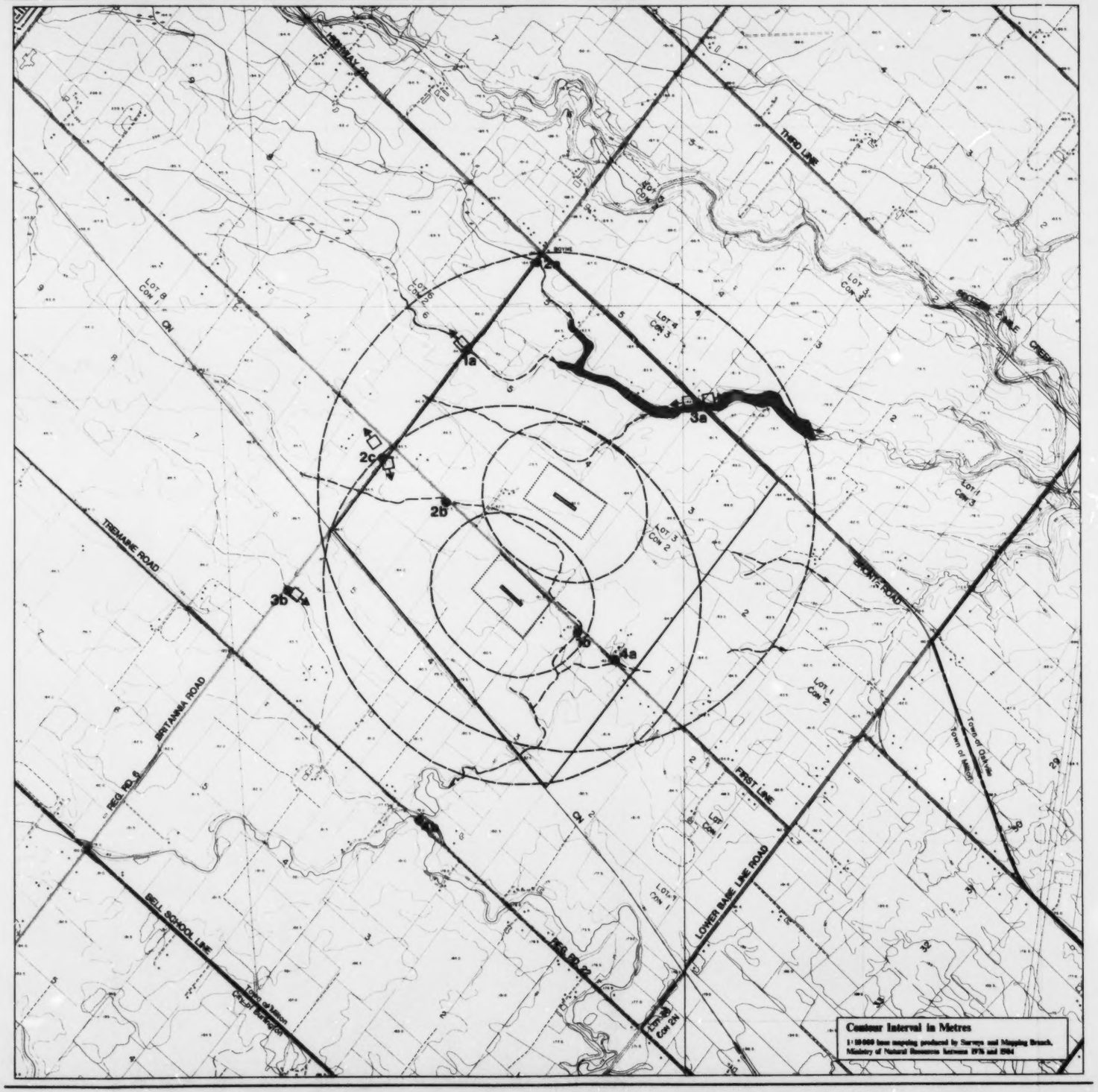
Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-3**

C.5 SITE PI-1N

Site PI-1N is located on the Halton Till Plain several km southeast of Milton. The till plain is very gently rolling at this site.

The Halton Till is the major surface unit at the site. An intermittent surface veneer of sand, silt or clay may be present locally. The Halton Till is a clayey silt till which contains several subunits with slightly differing physical characteristics. The till is also known to contain occasional sand lenses and may contain significant quantities of shale bedrock locally. It is commonly 10 to 15 m in thickness but may be thicker locally where bedrock valleys occur. The presence of an older sandy silt till and an underlying sand unit have been demonstrated in the area and site PI-1N appears to lie along the same bedrock valley trend noted in site LF-4N. There are approximately two dozen wells in and around the site. These indicate 15 to 20 m of "clay" which occasionally contains sand zones. There is commonly a sand zone noted resting on bedrock. The wells generally penetrate to bedrock for their water supply but several wells terminate in the sand zone overlying bedrock. The bedrock in the area is the red shale of the Queenston Formation. The site appears to lie over a broad bedrock valley which is eroded into the shale and is largely filled with till.



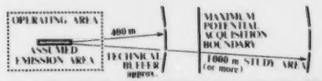
OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

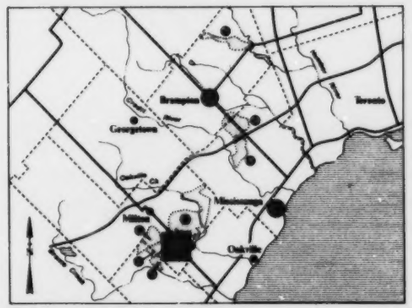
Legend:

- Till Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **PI-1 North**

Lots 3, 4 and 5; Concession II; Town of Milton; Parts of Lots 3, 4 and 5; Concession I; Town of Milton, formerly in the Township of Trafalgar



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-4**

C.6 SITE PI-13N

Site PI-13N is located on the Halton Till Plain approximately 2 km south of the town of Drumquin. The topography is very gently rolling and a creek cuts the site in an approximately east-west direction and is dammed in the east corner of the property.

The main geologic unit on the site is the Halton clayey silt till. This till is locally known to contain several subunits exhibiting slightly different physical characteristics. The till is also known to contain occasional granular lenses, may overlie silt and sand, and may be intermixed with the underlying shale bedrock. Water well data in the area is relatively plentiful and indicate approximately 5 to 12 m of till over bedrock. A few wells note sand (up to 3 m) occurring between the till and the underlying bedrock. Bedrock is exposed in the creeks to the northeast, east and south of the site. Preliminary field reconnaissance suggests that the till may not be as thick as the well logs indicate, based on observation of the road cuts in the area.

OWMC Ontario Waste Management Corporation

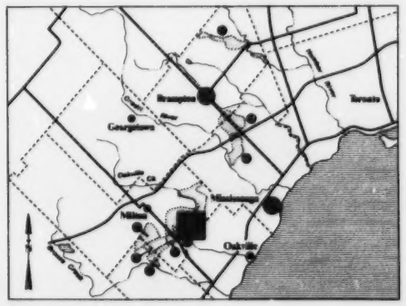
Consultant:
Gartner Lee Associates Limited

Legend:

- Till Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

Key Map: **PI-13 North**

Lots 3 and 4; Concession VI; Town of Milton, formerly the Township of Trafalgar



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

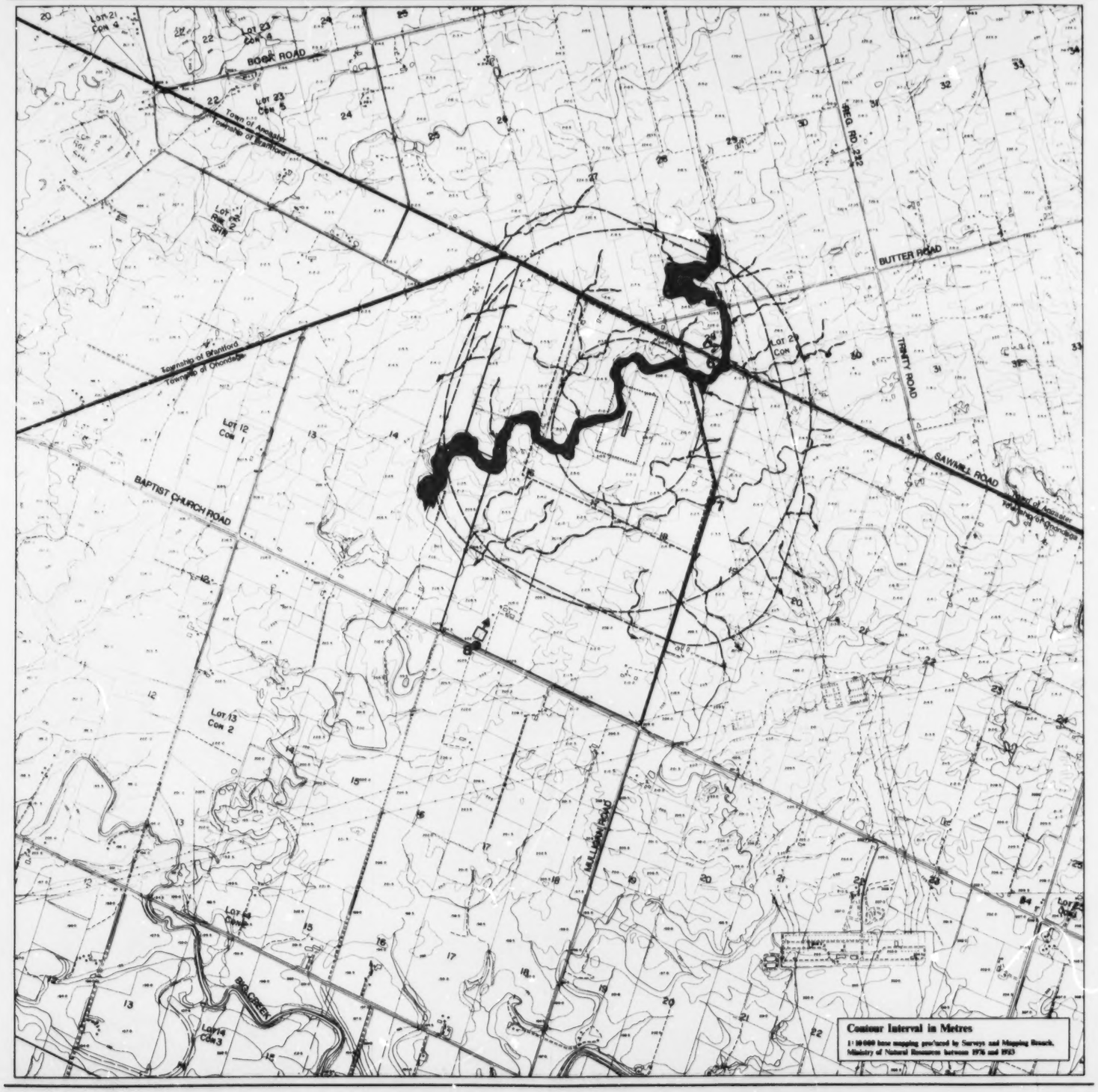
October 1984 **FIGURE C-5**

C.7 SITE LF-10W

Site LF-10W is located approximately 9 km southwest of Duff's Corner, southwest of Hamilton. The site is located on the Haldimand Clay Plain, and has gently rolling topography.

The area contains a potentially thick sequence of glaciolacustrine materials, mainly silts and clays. Varves are fairly common in these materials and can take the form of fine sand layers up to one m in thickness. This entire sequence is equivalent to the three silt-clay units documented in much of the Niagara Peninsula. The regional geology suggests the possibility of several m of sandy silt Wentworth Till occurring between the silt and clay, and the bedrock. Water well data from six wells near the site indicate 22 to 23 m of "clay". Ten wells to the west of the site indicate less, approximately 10 to 15 m of "clay" and wells to the north indicate 9 to 24 m of "clay". Many of the wells terminate within the "clay" sequence. A significant number employ large diameter casings and rely on storage to sustain yield during peak usage periods.

The variable depths of wells and the large casings suggest very strongly that the wells in the area are drawing water from thin sand varves in the sequence. Some wells in the area penetrate through the sequence of varved silts, clays and sands and obtain water from the underlying dolostone of the Guelph Formations.



OWMC Ontario Waste Management Corporation

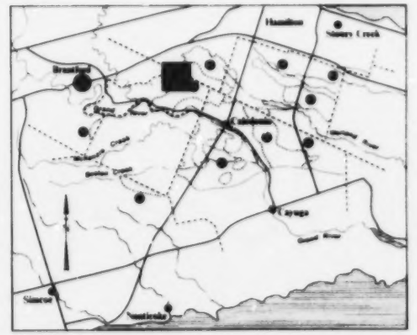
Consultant:
Gartner Lee Associates Limited

Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

Key Map: **LF-10a West**

Lots 16, 17 and Part of Lots 15 and 18; Concession 1; Township of Onondaga



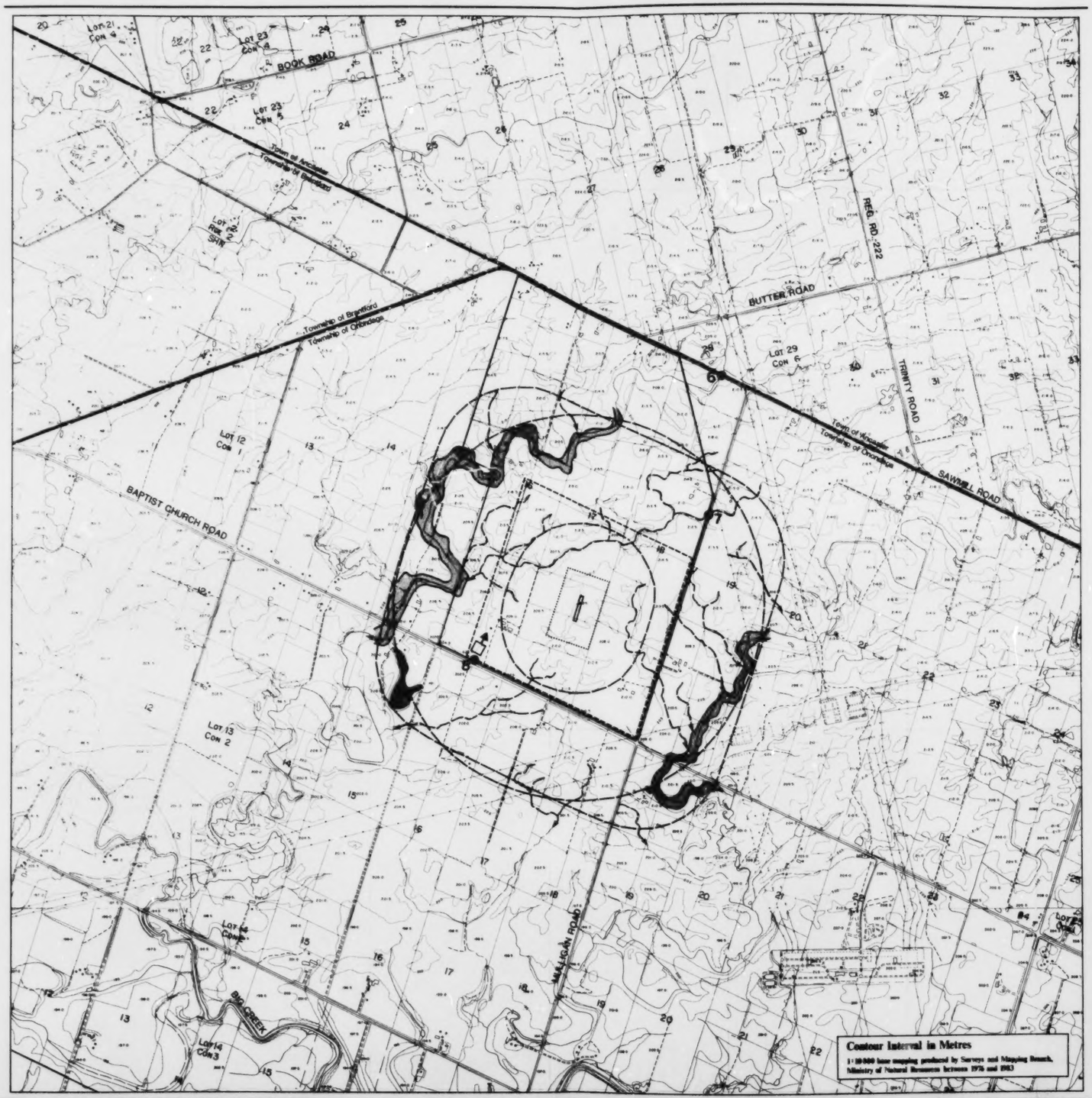
Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-6**

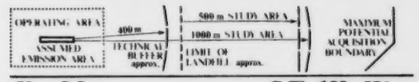


OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

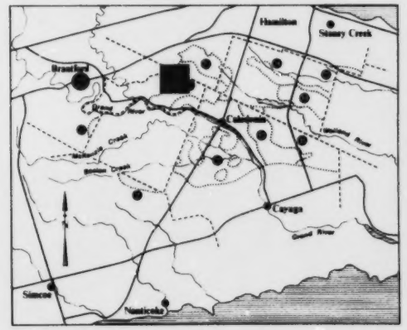
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-10b West**

Lots 16, 17 and Part of Lots 15 and 18; Concession I; Township of Onondaga



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

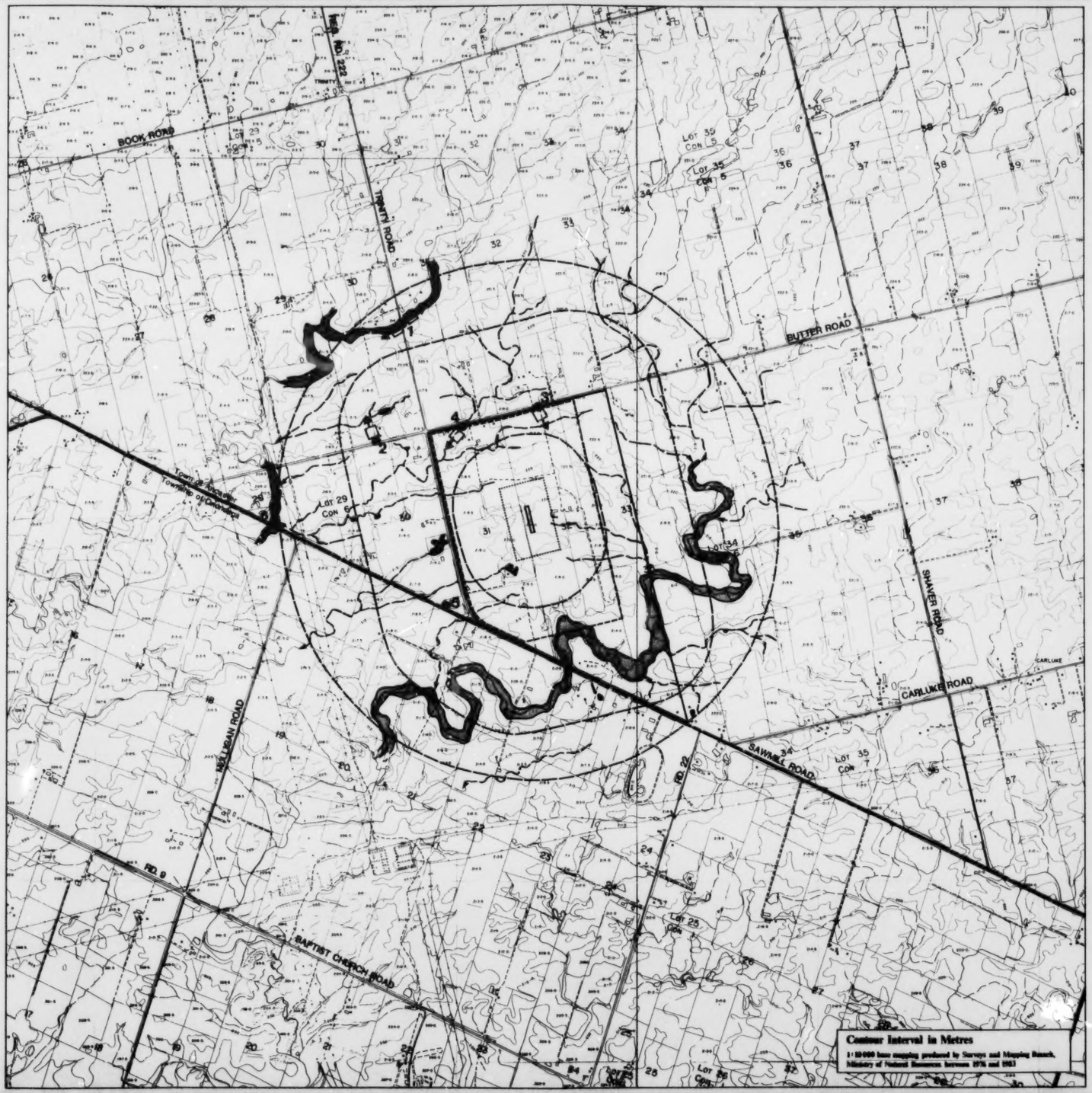
Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-7**

C.8 SITE LF-11W

Site LF-11W is located approximately 7 km south of Duff's Corner, southwest of Hamilton. The site comprises a portion of Haldimand Clay Plain and has gently rolling topography.

The area contains a potentially thick sequence of glacio-lacustrine materials, mainly silts and clays. Varves are fairly common in these materials and can take the form of fine sandy layers up to a metre in thickness. The entire sequence is equivalent to the three silt-clay units noted in much of the Niagara Peninsula. The regional geology suggests the possibility of several metres of sandy silt Wentworth Till occurring between the silts and clays and the underlying bedrock. Ten wells on or adjacent to the site indicate 18 to 26 m of uninterrupted "clay". Many wells in the surrounding area indicate similar clay thicknesses but there is a scattering of wells showing thinner clay (4, 8, 9, 15 m). These wells probably indicate the presence of a few scattered sand zones within the silt-clay sequence. Most wells in the area penetrate to the Guelph Formation dolostone aquifer.

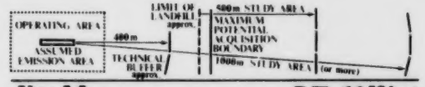


OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

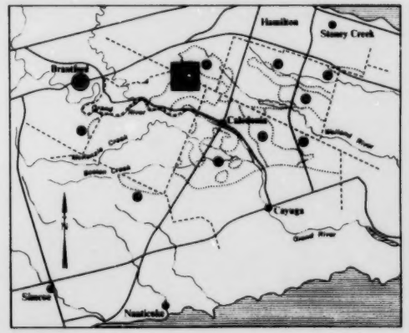
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-11 West**

Lots 31, 32 and Part of Lot 33, Concession VI; Town of Ancaster



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

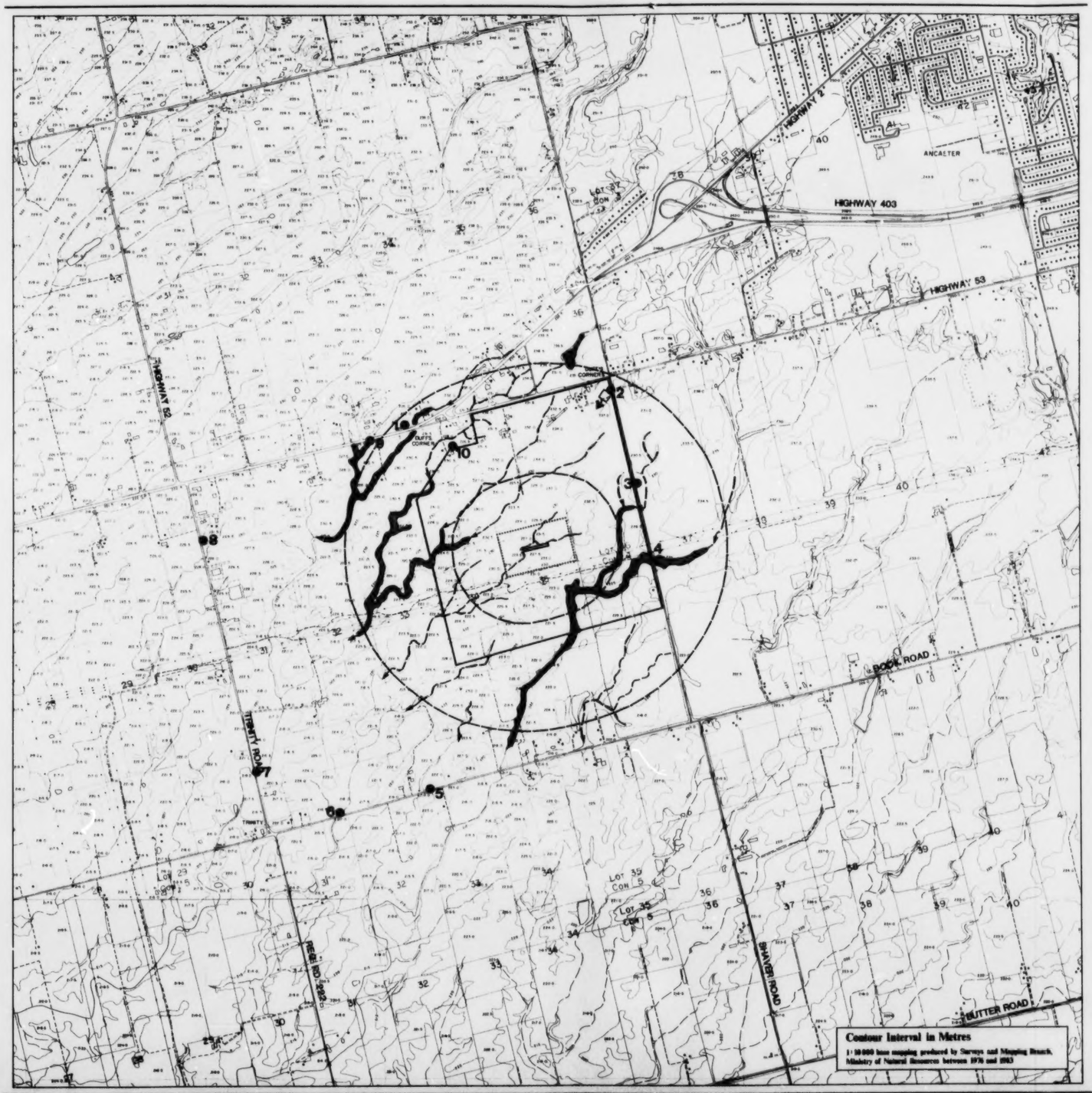
Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-8**

C.9 SITE PI-2W

Site PI-2W is located approximately a km south of Duff's Corner, southwest of Hamilton. It is located on the north-western edge of the Haldimand Clay Plain and exhibits rolling to gently rolling topography.

The area contains a potentially thick sequence of silt and clay glaciolacustrine materials. These materials contain varves which occasionally take the form of layers of fine sand up to one m in thickness. This entire sequence is equivalent to the three silt-clay units noted in much of the Niagara Peninsula. The regional geology suggests the possibility of several m of sandy silt Wentworth Till occurring between the silts and clays and the underlying bedrock. The regional pattern also suggests that there may be some subsurface variability in the subsurface associated with the Fort Erie Moraine in the Mount Hope area. There are approximately a dozen wells within the area of site PI-2W. The "clay" thickness ranges from 0 m (where sand is at surface) to 32 m. The average thickness is around 20 m. A similar level of inconsistency is noted in wells slightly more distant from the site. Variable thicknesses of "clay" may result from sand either at surface or within the silt-clay glaciolacustrine sequence. Most wells in the area penetrate to the dolostone aquifer of the Guelph Formation.

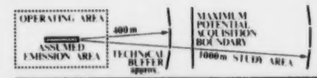


OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

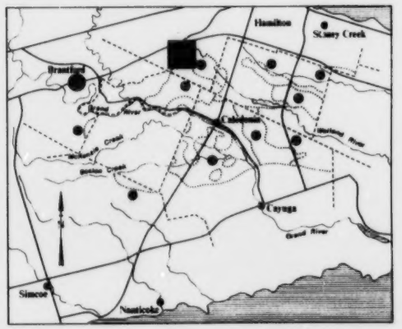
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **PI-2 West**

Part of Lots 34, 35 and 36; Concession IV; Town of Ancaster



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-9**

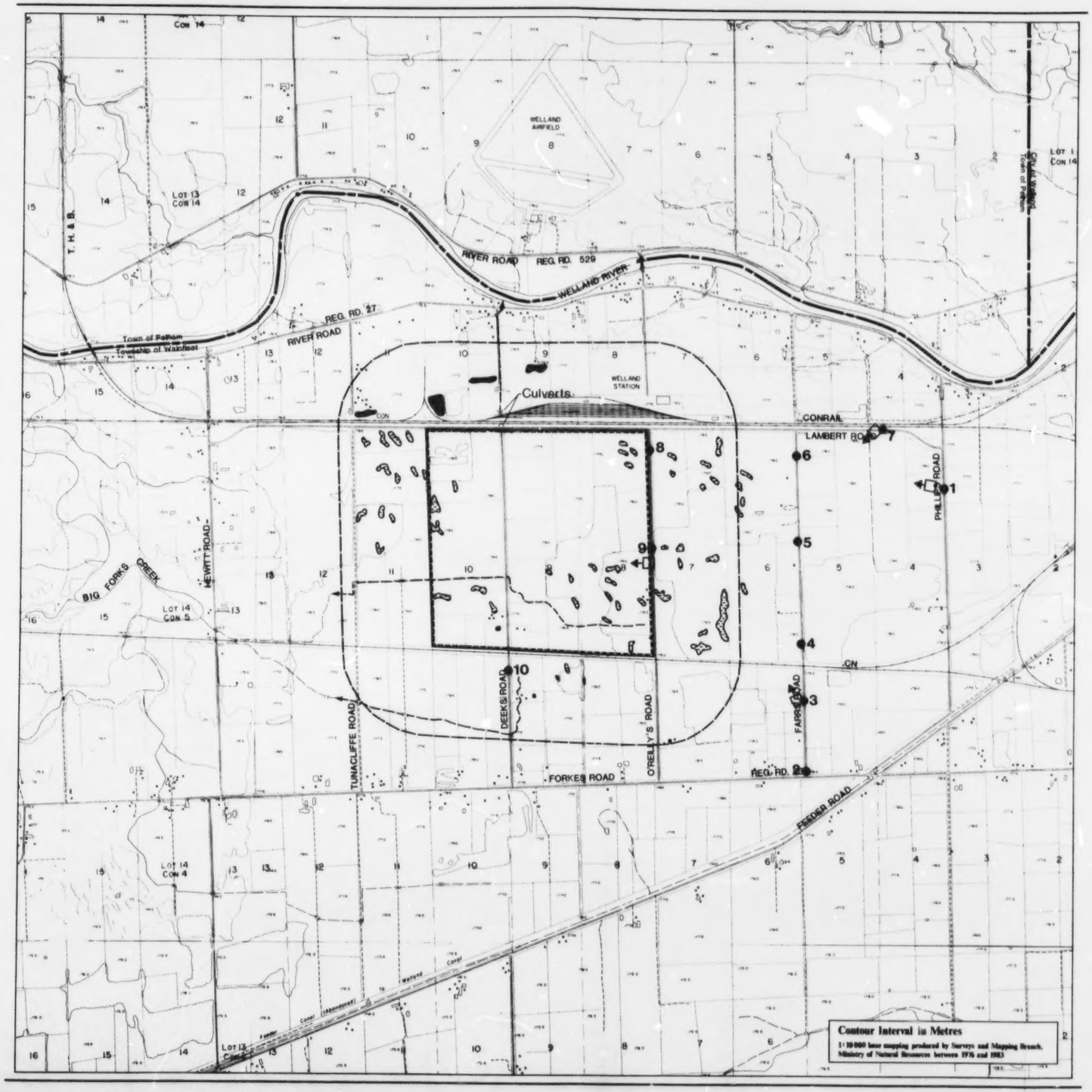
C.10 SITE LF-1C

Site LF-1C is located west of Welland on the south side of the Welland River, approximately 2 km south of the Welland Airport.

The site is located on the Haldimand Clay Plain and is underlain by glaciolacustrine clay and silt. The land surface is nearly flat and there are numerous wet and poorly drained areas on the property with no major streams developed. The regional geology would suggest the presence of the silty clay Halton Till beneath the surface glaciolacustrine materials and a second unit of glaciolacustrine silt-clay underlying the till. Only minor variability has been noted in these units regionally, and the three units together comprise the "clay" noted in the driller's log on drill records. "Clay" thicknesses noted in approximately a dozen water wells in the vicinity of the site range from 26 to 39 m. Two wells to the north of the site record similar thicknesses of "sand" and these are regarded as anomalous and would need to be evaluated in subsequent evaluation. Regionally several metres of "sand" may be encountered between the "clay" and the underlying bedrock.

This "sand" may be the Wentworth sandy silt till and/or sand which often occurs with it. Although the "sand may occasionally yield quantities of water suitable for domestic use, most wells penetrate into the underlying fractured dolostones and shales of the Salina Formation which is the main aquifer for the area.

There are no known or suspected moraines in the immediate vicinity of the site and the site is situated in one of the thickest areas of "clay" within the Niagara Peninsula.



OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

Legend:

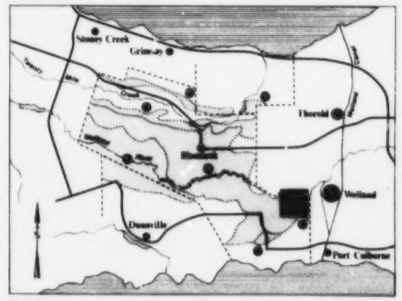
- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

LIMIT OF LANDFILL approx. — not to scale

MAXIMUM POTENTIAL ACQUISITION BOUNDARY — 500 m STUDY AREA

Key Map: **LF-1 Central**

Part of Lots 8, 9, and 10; Concession V; Township of Wainfleet



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-10**

C.11 SITE LF-3C

Site LF-3C is located on the north side of the Welland River several km west of Wellandport. The site is situated on a gently rolling portion of the Haldimand Clay Plain and is bounded on the north and south by sizeable creeks which drain into the Welland River.

The silt-clay exposed in the clay plain is the uppermost of three units of similar composition in the region. The upper and lower units are glaciolacustrine clayey silts and silty clays and these two are separated by the clayey silt Halton Till. The three are closely related geologically and historically and are commonly referred to in well drillers' logs as a single unit of "clay". The "clay" occasionally overlies "sand" and/or "hardpan" which overlies bedrock. The sand and/or hardpan is probably the sandy silt Wentworth Till, perhaps with some sand, which often underlies the silt-clay in the area at depth and commonly reaches up to several metres in thickness. The sands and hardpan occasionally yield water in sufficient quantity for domestic supply, although most wells penetrate to the fractured dolostone and shale of the Salina Formation. There are three water well records available within 2 km of the site. They indicate between 24 and 29 m of "clay". One well terminates in "hardpan" and the other two encounter bedrock.

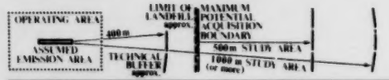
The possible subsurface traces of the Fort Erie and Port Maitland Moraines are inferred in the general area but they are not believed to enter the area of the site itself.

OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

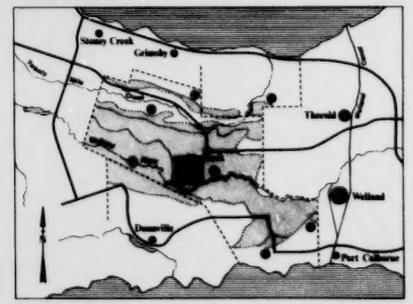
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-3 Central**

Lots 5, 6 and 7; Concession 1; Part of Lot 7; Broken Front Concession; Township of West Lincoln; formerly in the Township of Gainsborough



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-11**

C.12 SITE LF-8C

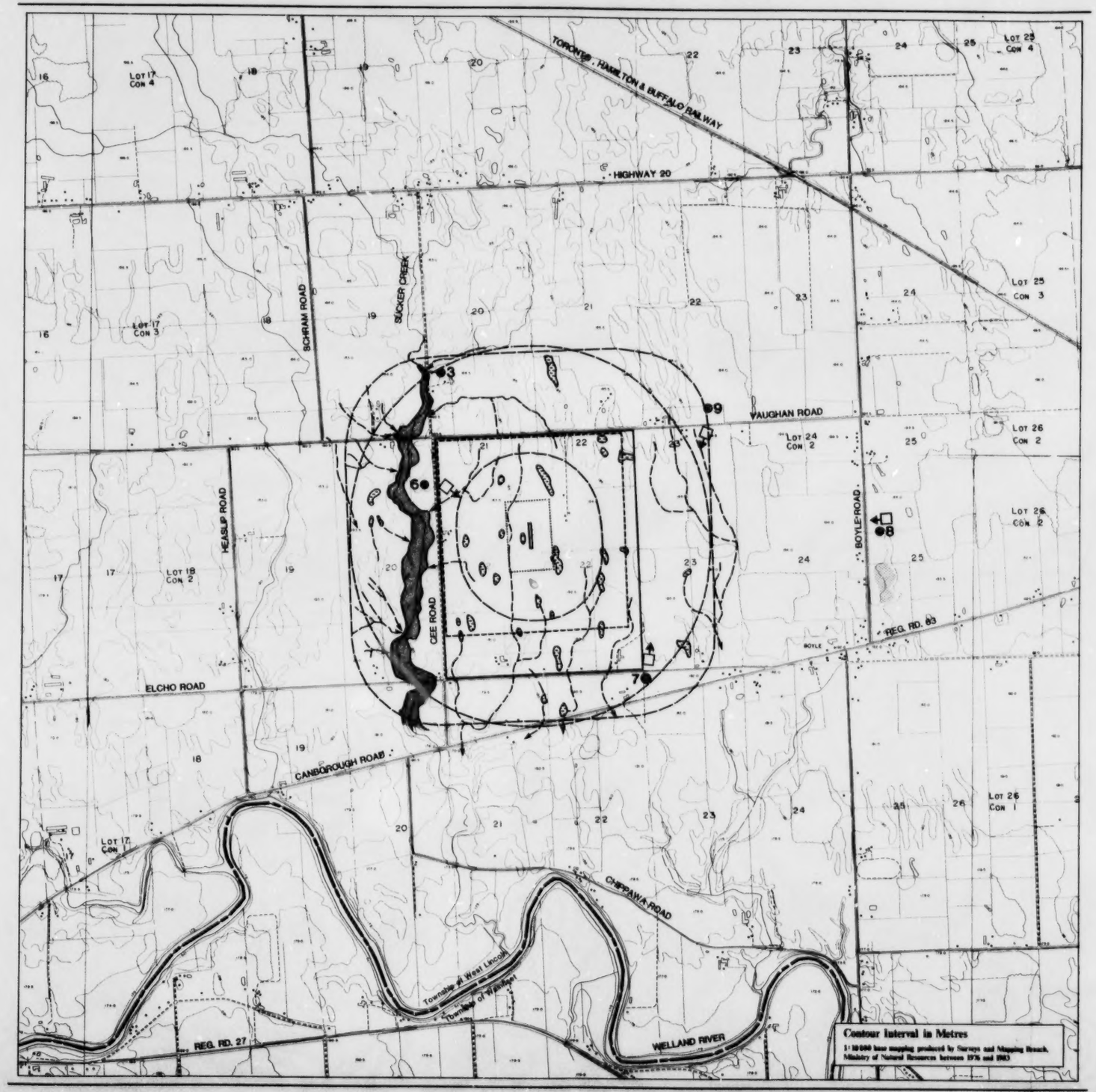
Site LF-8C is located approximately 5 km northeast of Welland-port, near the town of Boyle. It is located on the Haldimand Clay Plain and exhibits gently rolling relief.

The geology of the site is dominated by three silt-clay units which are closely related geologically and historically. The upper and lower members of the group are glaciolacustrine clayey silts - these are separated by the clayey silt Halton Till. On a regional basis these three units are quite thick and contain minimal variability. Water well drillers often refer to the three units together as "clay", and records from three wells near the site indicate between 37 and 43 m of "clay". One additional well south of the property notes a similar thickness of materials (42 m) but composed of "medium sand gravel". This is contrary to both the regional geologic pattern and to the other records in the vicinity -- its accuracy must be assessed in subsequent investigations. All wells terminate in the bedrock aquifer.

The northern half of the site is underlain by the dolostone of the Guelph Formation, the southern half of the site is underlain by the dolostone and shale of the Salina Formation. Regionally there is a thin (to several m) intermittent layer of sand and/or sandy silt Wentworth Till between the "clay" and the bedrock.

The limited amount of subsurface data available for the site renders appraisal of subsurface conditions very general in nature. There are two possible sources of subsurface variability which occur several km distant from the site but

are not presently known to affect the site itself. There is an inferred trace of the Fort Erie Moraine north of the site -- there is no direct evidence of this buried feature to date but further study on the site should recognize its potential presence. The other potential source of subsurface variability is associated with the buried apron of the Fonthill Kame. This feature is not expected to encroach on the site but future study should be cognizant of this possibility.



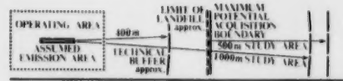
OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

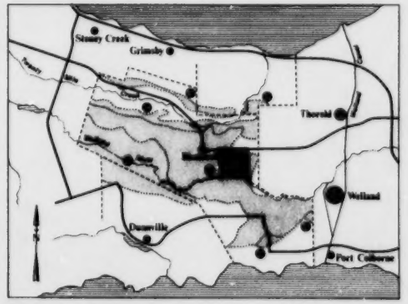
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-8 Central**

Lots 21 and 22; Concession II; Township of West Lincoln; formerly in the Township of Gainsborough



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-12**

C.13 SITE LF-9C

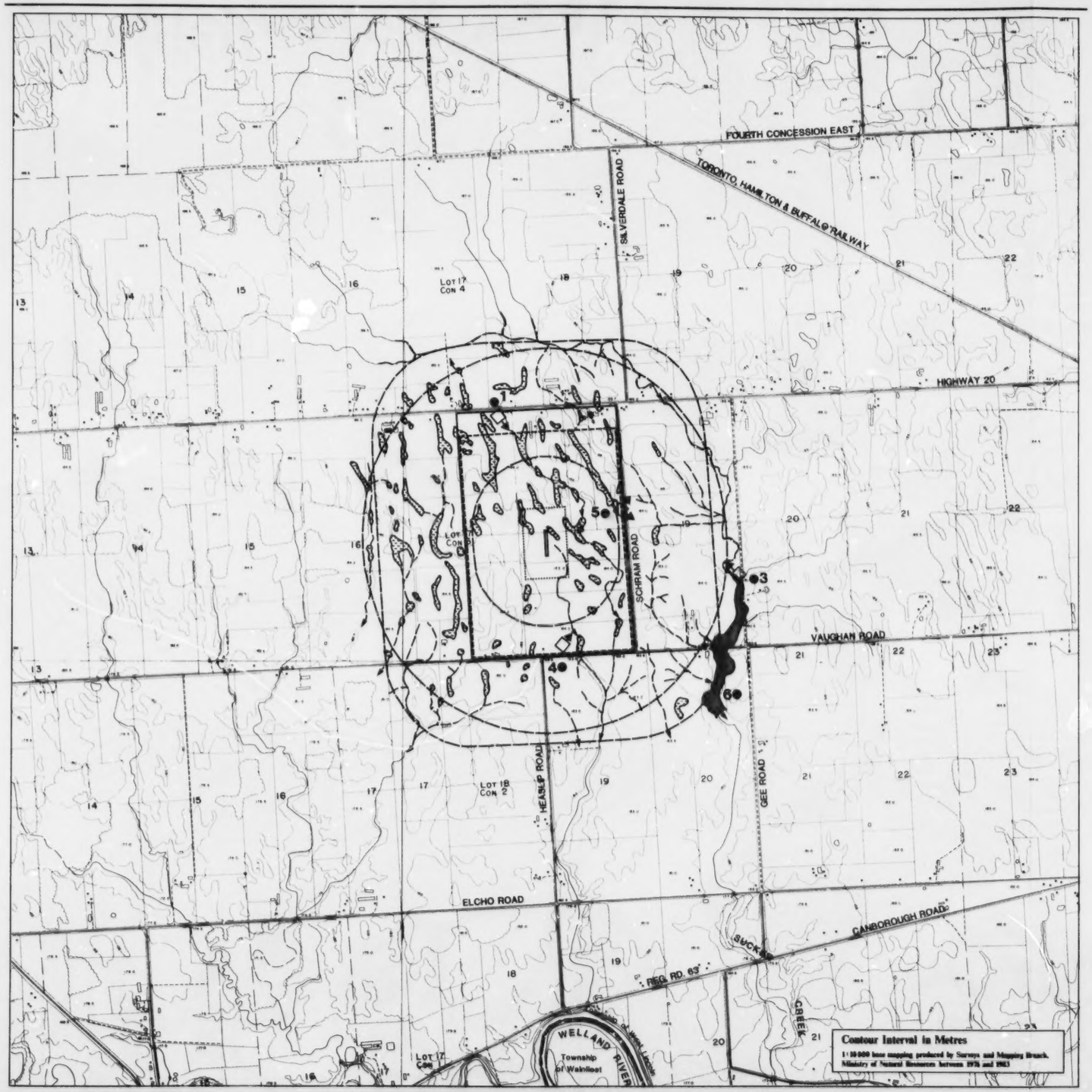
Site LF-3C is located on the Haldimand Clay Plain, on the south side of Highway 20, approximately 6 km west of Bismark. It is a gently rolling area containing occasional poorly drained depressions.

The geology of the site is dominated by thick sequences of three silt-clay units. Two units of glaciolacustrine clayey silt are separated by the clayey silt Halton Till. Water well drillers often note these three units together as "clay". A dozen wells within a km of the site not 29-37 m of "clay" in the vicinity of the site. One well, located approximately a km east of the site records approximately 10 m of "clay" overlying "red sand". Red sand is typical of the Fonthill Kame and it is possible that this buried lens of sand is similar to those described previously in the apron of the kame. There are a number of occurrences of several m of sandy materials between the "clay" and the underlying dolostone of the Guelph Formation.

This zone of sandy material may be the sandy silt Wentworth Till and/or sand which occurs regionally in this position. It is commonly up to several m thick. A few wells obtain sufficient water for domestic purposes form this sand/till unit but most wells penetrate to the bedrock which is the main aquifer in the area.

There are two possible sources of subsurface variability in the vicinity of site LF-9C. Both sources are speculative and inferred at present and would have to be investigated in subsequent studies. The trace of the Fort Erie Moraine has been inferred in the general area. Its exact position, and

even its existence in the area, has yet to be proven. Subsurface variability associated with the Fonthill Kame has been demonstrated in previous study to the east of site LF-9C. It is not known if this variability extends as far west as the present site and future work on the site would have to address this possibility.



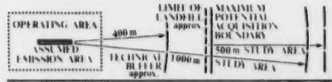
OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

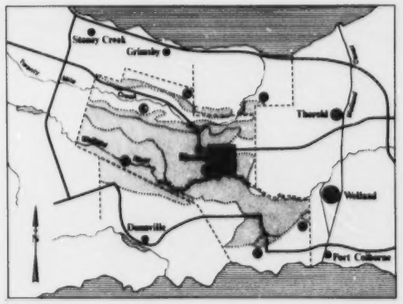
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-9 Central**

Lot 18 and Part of Lot 17; Concession III; Township of West Lincoln; formerly in the Township of Gainsborough



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

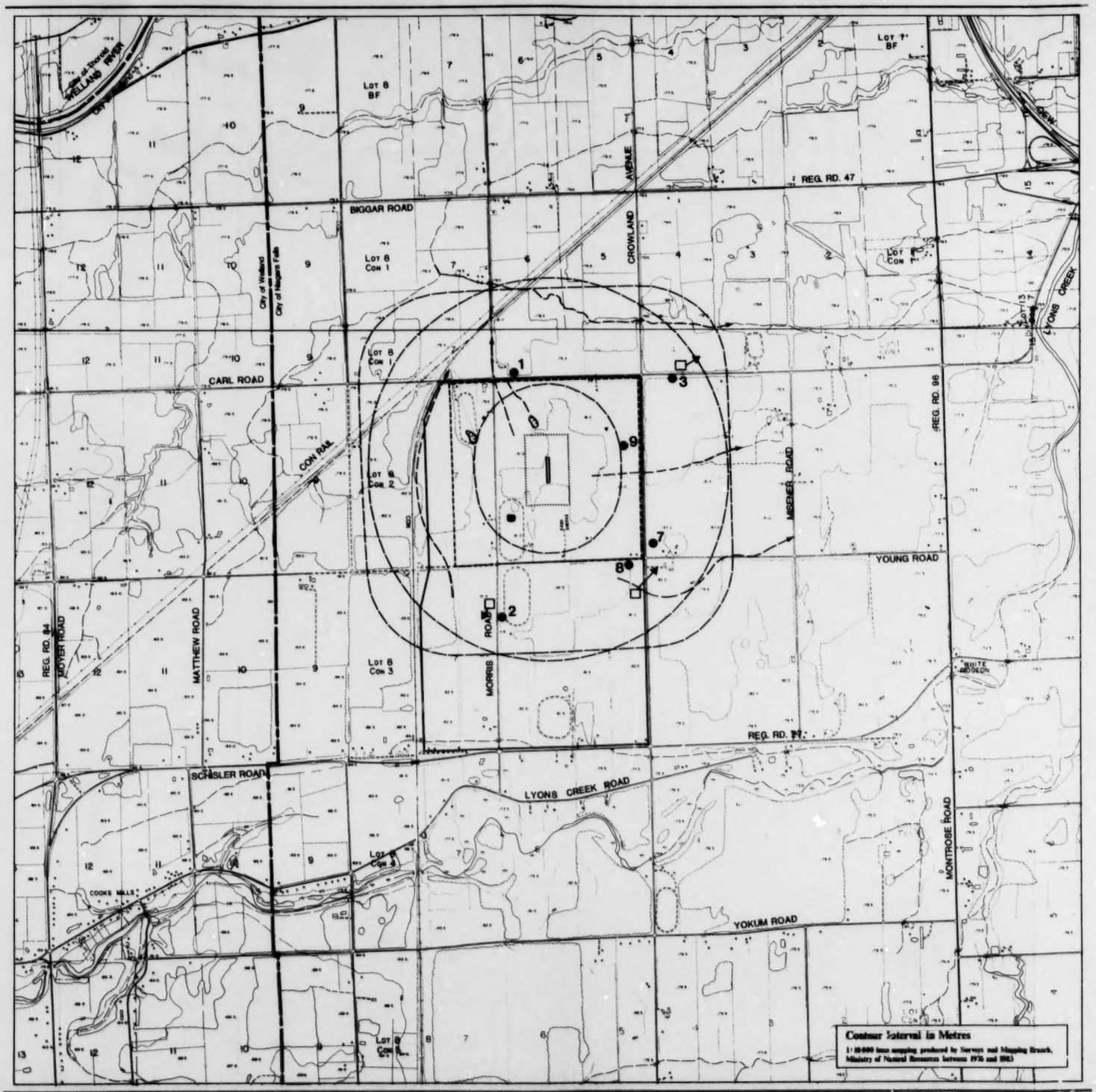
October 1984 **FIGURE C-13**

C.14 SITE LF-1E

Site LF-1E is located approximately 10 km south-southeast of Niagara Falls and a similar distance east of Welland. It is situated on the flat Haldimand Clay Plain several km east of the Fort Erie Moraine.

Geologic studies in the area record a sequence of three silt clay units in the general area of site LF-1E: an upper glaciolacustrine unit which is exposed at surface, the Halton Till, and a lower glaciolacustrine unit. The Halton Till is rarely found at surface and the lower glaciolacustrine silt-clay is buried. These three units are closely related geologically and are often referred to collectively as "clay" in the water well records. There are no water wells recorded in the candidate site but nearby wells suggest 20 to 25 m of clay is present at the site. A sandy silt till is known to underlie this "clay" sequence in many parts of the Niagara Peninsula, including site LF-1E. "Sand" is often recorded either with, or in place of, this lower till in many of the water well logs. This lower till may be the Wentworth Till. It is commonly up to several m thick but is not noted in all water wells in the region. This lower sand or sandy till may locally yield sufficient water for domestic supply and occasional wells terminate in this unit. It also directly overlies the aquifer commonly used in the area - the fractured dolostone and shale of the Salina Formation. One well approximately 2 km southeast of the site reports an anomolous condition of 13 m of "quicksand" under only 9 m of "clay" - none of the surrounding wells record similar conditions. Water well data in the area are light.

There is an unusual, and as yet unexplained, topographic high at the southeast corner of the candidate site. The mound is approximately 4 to 5 m in relief and its shape and occurrence is generally suggestive of a partially buried morainic ridge such as those associated with the Fort Erie Moraine several km to the west of the site. Published mapping indicates that the surface of the mound is composed of the same silt-clay glaciolacustrine materials occurring in the adjacent flat clay plain. One unconfirmed possible gas well was noted south of the site during field reconnaissance.

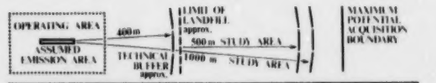


OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

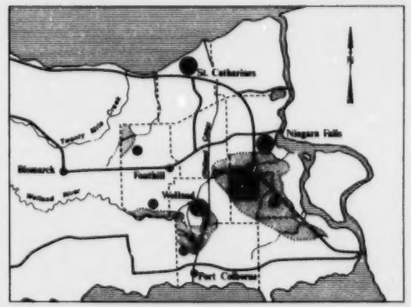
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-1a East**

Lots 5, 6 and 7; Concessions II and III; City of Niagara Falls; formerly in the Township of Crowland



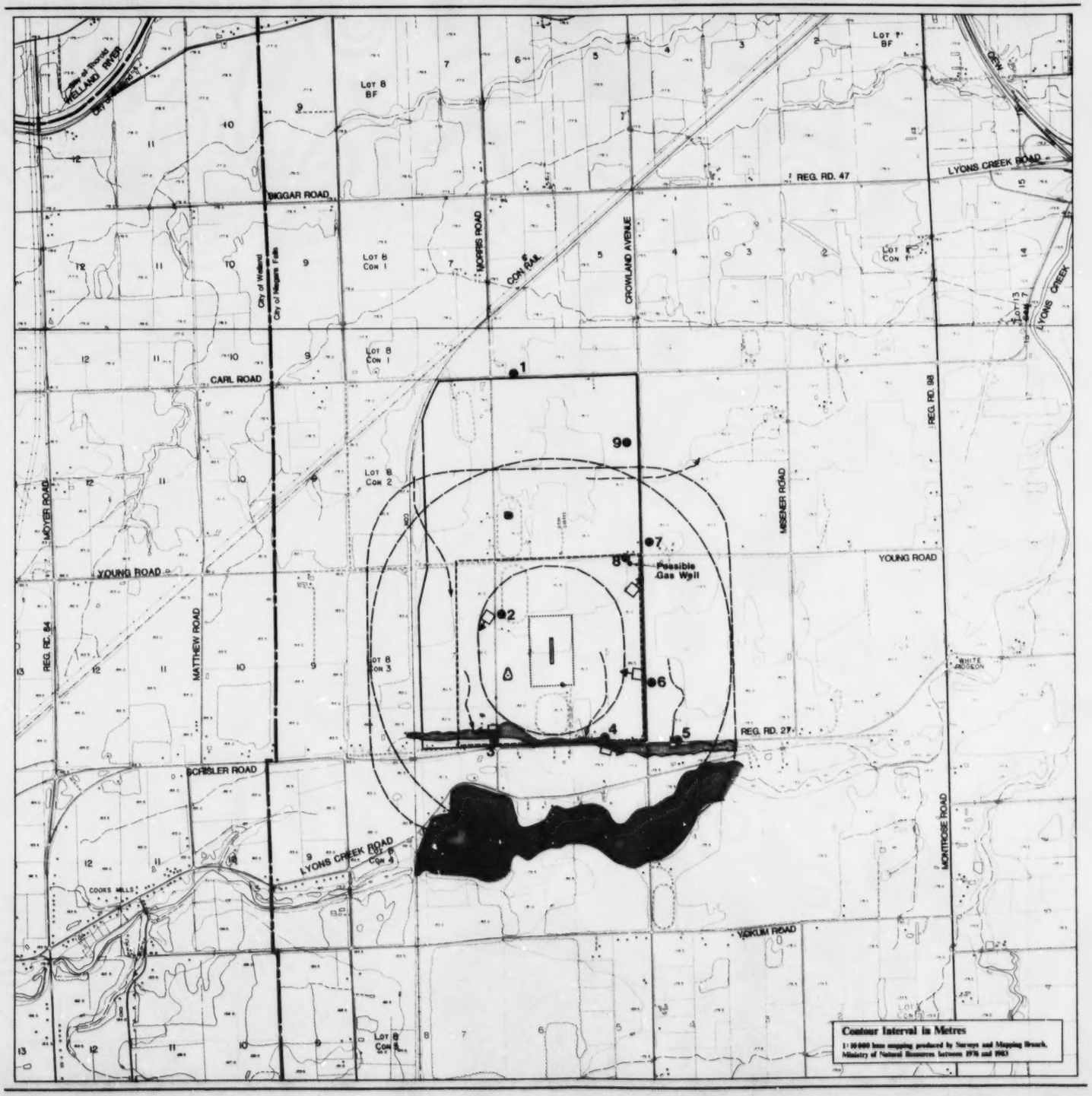
Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-14**



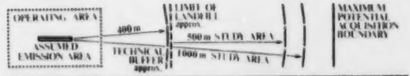
OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

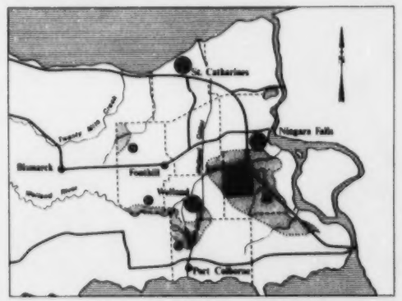
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-1b East**

Lots 5, 6 and 7; Concessions II and III; City of Niagara Falls; formerly in the Township of Crowland



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-15**

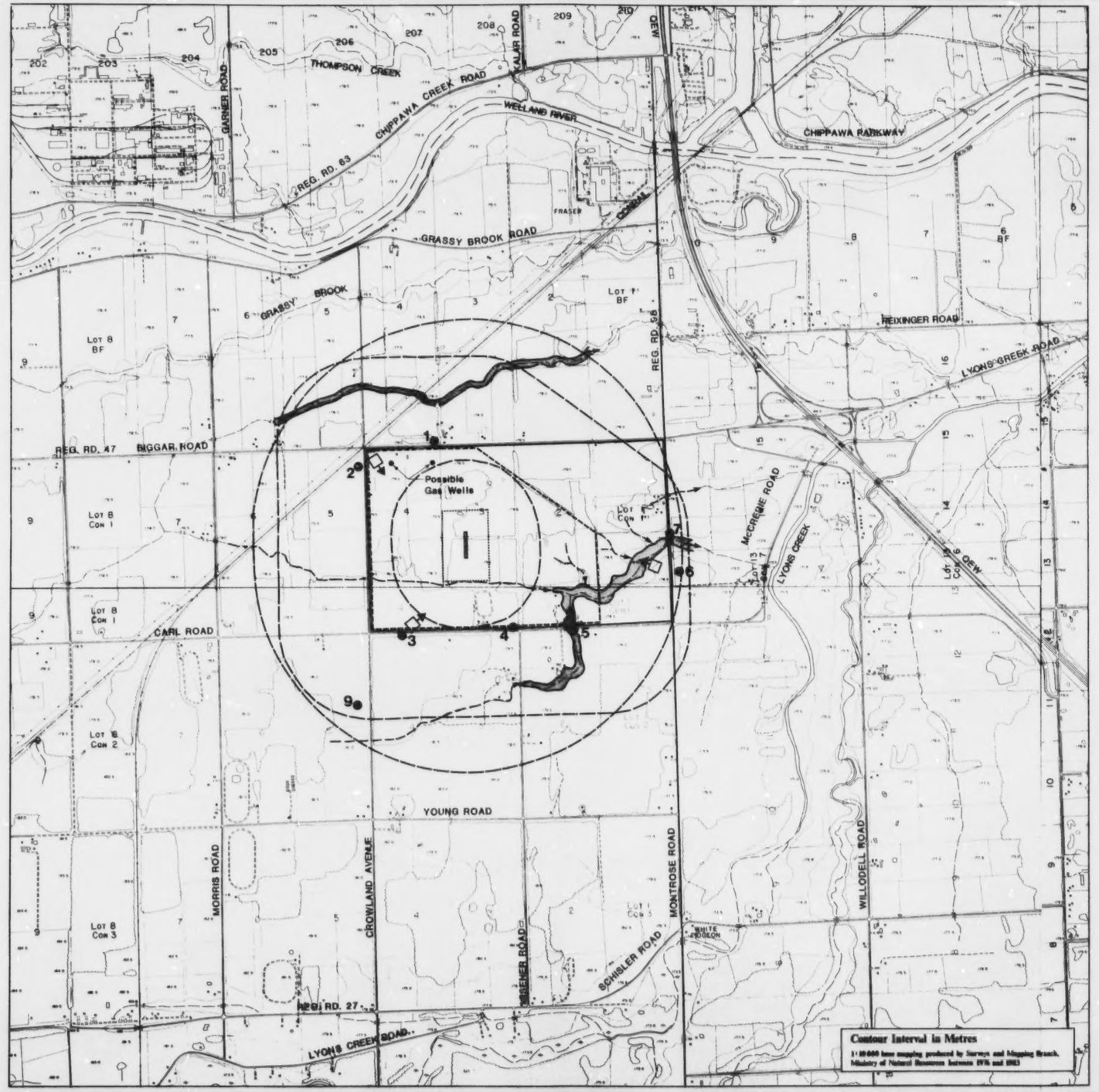
C.15 SITE LF-3E

Site LF-3E is situated two km south of the Welland River and a km west of the Queen Elizabeth Highway, approximately 8 km south-southwest of Niagara Falls. The site is located within the eastern portion of the Haldimand Clay Plain.

The site is generally flat to gently rolling with occasional small depressions. The regional geology records a sequence of three silt-clay units in the region: an upper glaciolacustrine unit, the Halton Till, and a lower glaciolacustrine unit. The upper glaciolacustrine silt-clay is commonly exposed at surface through the Niagara Peninsula, the Halton silt-clay till is occasionally exposed at surface and the lower glaciolacustrine silt-clay unit is buried beneath the other two units. These three silt-clay units are often referred to collectively as "clay" in the water well records. Well data occur sporadically around the site and indicate 10-24 m of "clay" in the immediate vicinity containing few sand lenses or inhomogeneities. Only one well occurs on the site but it is reasonable to infer 14 to 20 m of clay on the site with a probable increase to the south. A sandy silt till, possibly the Wentworth Till, and associated thin sand deposits occasionally underlie the "clay" materials in water well logs. Regionally the sandy silt till and the sand are several m thick and are noted in only a portion of the drill logs. The till and sand occasionally yield water in quantities sufficient for domestic supply. These materials directly overlie the major aquifer in the area - the fractured dolostone and shale of the Salina Formation.

The water well data immediately adjacent to site LF-3E generally reflect the regional pattern. There are, however, several occurrences of sand and/or sand till resting on bedrock which range up to 13 m in thickness. There are also several notations of sand lenses with the "clay" sequence. In most cases these wells continue to rock and obtain water from the bedrock aquifer.

There are several similar occurrences north of the site LF-3E, particularly around Montrose. Regional geologic relationships suggest two possible explanations - buried drumlins composed of the lower sandy silt till and the possible extension of subsurface variability associated with the Niagara Falls Moraine. The general dominance of silt-clay materials in the water well data suggests that any buried granular material will be limited in its geographic extent.

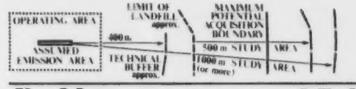


OWMC Ontario Waste Management Corporation

Consultant:
Gartner Lee Associates Limited

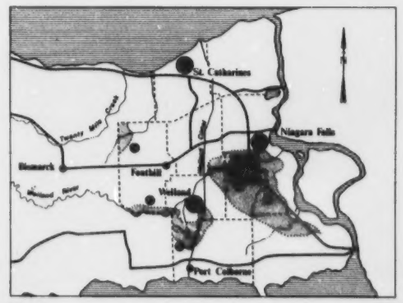
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **LF-3 East**

Lots 1, 2, 3 and 4; Concession I; City of Niagara Falls, formerly Township of Crowland



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-16**

C.16 SITE PI-18E

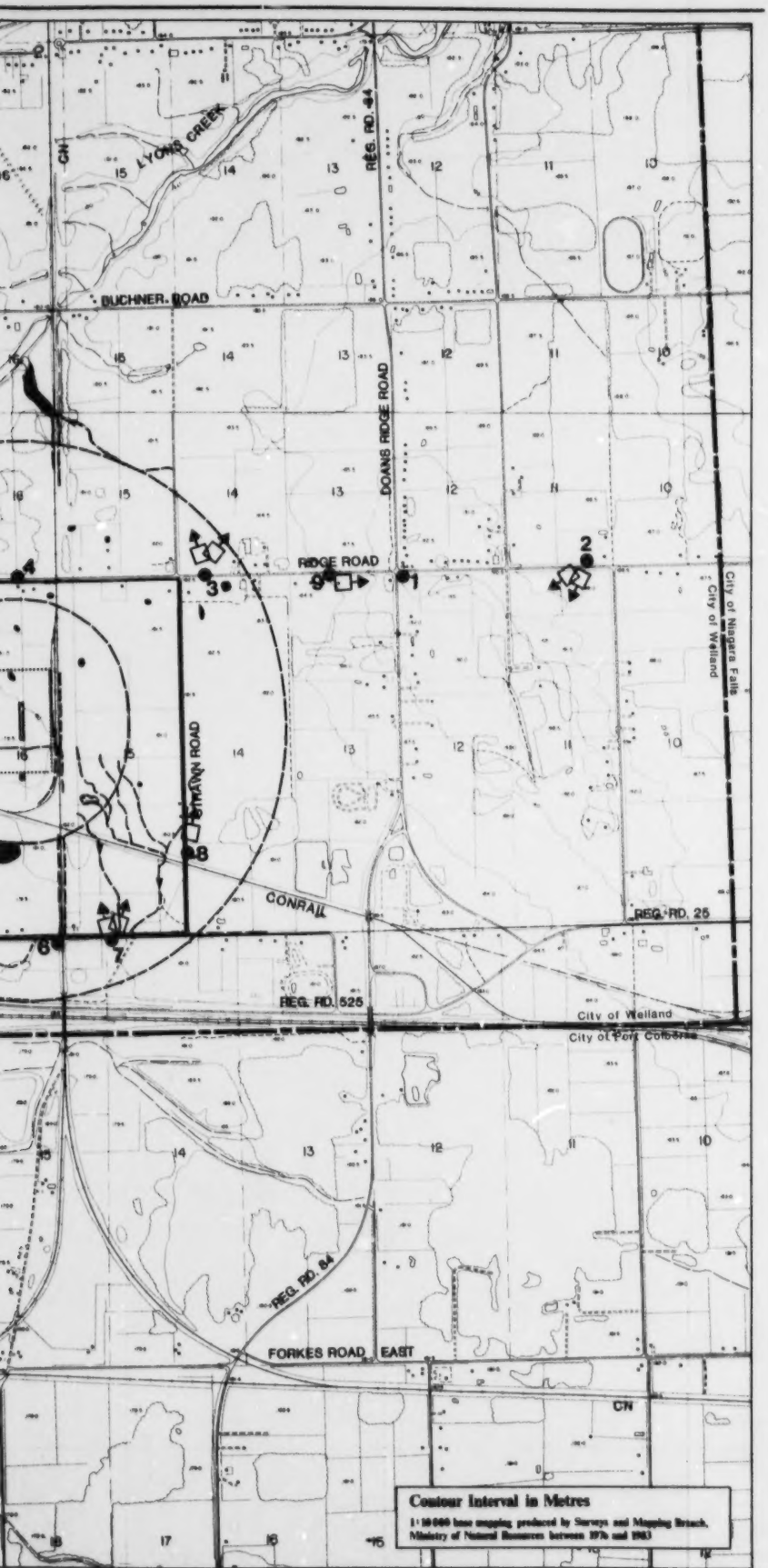
Site PI-18E is located on the southeast edge of Welland, east of the Welland Canal and north of Highway 58. The site is located on the Haldimand Clay Plain and the land is flat and poorly drained.

The geology of the area is dominated by two glaciolacustrine silt-clay units and the Halton silt-clay till which separates them. The upper glaciolacustrine silt-clay is exposed at surface on the site and throughout most of the Niagara Peninsula. The Halton Till occurs at surface occasionally in the Peninsula, notably along the crest of partially buried moraines such as the Fort Erie Moraine, approximately a km east of the site. The lower glaciolacustrine unit are expected to occur at depth beneath site PI-18E. These three silt-clay units are generally noted as "clay" in the well drillers' logs for the area. "Clay" thicknesses are expected to be between 20 and 40 m in the vicinity of the site, although there are no well data on, or immediately around the site. Regionally the "clay" is known to overlie a sandy silt till which is often associated with sand in the drillers' logs. This combined unit is commonly up to several m thick but may locally be thicker. Some wells obtain water from this till/sand unit but most penetrate the main aquifer in the area, the dolostone and shale of the Salina Formation, which underlies the till/sand and is probably connected hydraulically.

Several wells located east of the site on the Fort Erie Moraine suggest that there is subsurface variability associated with the moraine. Two wells located between the site and the moraine do not note any variability. There are no wells known

on the site. The entire sequence of materials was described as exposed in the excavations for the Welland Canal, approximately 2 km west of site PI-18E. These descriptions note the presence of approximately 25 m of clay and silt-clay materials of glacial and glaciolacustrine origins and indicate minor variability.

WELLAND
WELLAND CANAL
RUSHOLME ROAD
NETHERBY ROAD
HIGHWAY 58A
CONRAIL CN
CN
HIGHWAY 140
REG. RD. 28
LOT 20 CON 5
LOT 20 CON 6
LOT 20 CON
LOT 18 CON 3
LOT 22 CON



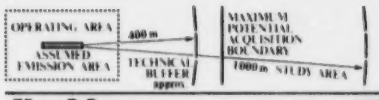
OWMC Ontario Waste Management Corporation

Consultant:

Gartner Lee Associates Limited

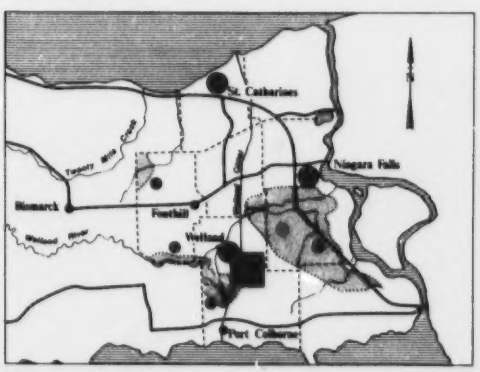
Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation



Key Map: **PI-18 East**

Lots 15, 16 and Part of Lot 17; Concession VII; City of Welland, formerly in the Township of Crowland



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-17**

C.17 SITE PI-27E

Site PI-27E is located south of the Welland River on the west side of the Queen Elizabeth Highway, approximately 6 km south-southwest of Niagara Falls. The site is part of the Haldimand Clay Plain which slopes gently to the east. Two streams which have small flood plain areas flow from west to east across the site.

The geology of the area is dominated by three silt-clay units: an upper glaciolacustrine unit, the Halton Till, and a lower glaciolacustrine unit. The upper glaciolacustrine silt clay is exposed at surface on the site and throughout most of the Niagara Peninsula. The Halton Till is exposed occasionally and the lower glaciolacustrine unit is buried. Both of these units are expected to underlie the site at depth. These three units are commonly referred to as "clay" in the water well logs and average 14 to 20 m on site PI-27E. A sandy silt till and/or sand is often noted beneath the three silt-clay units, resting on rock. The sandy silt till may be the Wentworth Till and the till and the accompanying sand occasionally yields enough water for domestic purposes. It overlies and is hydraulically connected to the major aquifer in the area - the fractured dolostone and shale of the Salina Formation. The till and sand averages several metres in thickness regionally, but it is noted in all wells.

The water well data on and immediately adjacent to the site reflect the general regional patterns of 15 to 20 m of silt-clay. There are, however, several occurrences of sand thicker than the regional average (to 13 m in thickness). There are also several notations of sand lenses within the "clay"

sequence. In most cases these wells terminate in bedrock or close to the expected bedrock elevations and obtain water from the bedrock aquifer or the overlying till/sand unit. There are several similar occurrences north of the Welland River, near Montrose. The general dominance of silt-clay materials in the water well data suggests that any buried granular will be limited in geographic extent. Regional geologic relationships suggest two possible explanations - buried drumlins composed of the lower sandy silt till, and a possible subsurface extension of subsurface variability associated with the Niagara Falls Moraine.

OWMC Ontario Waste Management Corporation

Consultant:

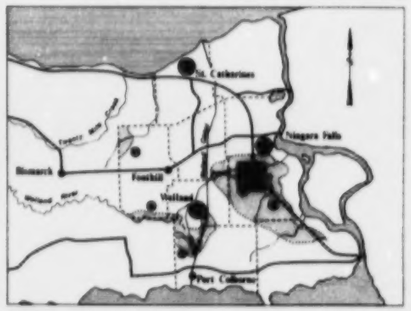
Gartner Lee Associates Limited

Legend:

- Clay Plain
- Moraine
- Flood Plain (approximate)
- Wetland
- Pond
- Stream Course (usually intermittent swales)
- ●5 Observation Location
- Photograph Location & Orientation

Key Map: **PI-27 East**

Part of Lots 1, 2, 3, and 4; Broken Front Concession Welland River; City of Niagara Falls; formerly in the Township of Crowland



Notes:

- Based on published information with limited field checking.
- Findings are subject to confirmation following site-specific study.

1000 feet 0 1000
500 metres 0 500

Physical Resource Features CANDIDATE SITE IDENTIFICATION

October 1984 **FIGURE C-18**

APPENDIX D

IDENTIFICATION OF CANDIDATE SITES (Access Route Analysis)

APPENDIX D IDENTIFICATION OF CANDIDATE SITES

(Access Route Analysis)

CONTENTS

TABLE	PAGE
D-1 Access Route Analysis	D - 1

Note: Individual access routes are ranked in order of the length of Sensitive lands crossed by the route. As an example, an alternate route with 100 m of sensitive lands would receive a lower ranking than a route with 80 m

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
LF-4N	401 - Hwy. 25 - Steeles - First Line - Britannia Rd.	400	-	2
	401 - Hwy. 25 - Steeles - Tremaine	-	350	1
	401 - Fourth Line - Derry Rd. - Fifth Line - Britannia	200	250	3
	401 - Trafalgar Rd. - Britannia Rd.	-	5850	7
	403 - Winston Churchill Blvd. - Britannia Rd.	-	2650	5
	QEW - Trafalgar Rd. - Britannia Rd.	-	2950	6
	401 - Fourth Line - Britannia Rd.	-	1400	4 *
	QEW - Hwy. 25 - Britannia Rd.	-	1400	4 *
LF-2N	401 - Hwy. 10	-	-	1 *
	410 - Derry Rd.	-	-	1 *
LF-10W	403 - Hwy. 2 - RR22 - Sawmill Rd.	-	1850	1 *
LF-11W	403 - Hwy. 2 - RR22	-	1850	1 *

* OWMC preferred access route to site

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
LF-1C	406 (proposed) - RR27 - Hwy.140 - Netherby Rd. - Rusholme Road. Townline Rd. - Hwy 58 - RR23 - O'Reilly's Rd.	-	5100	2
	406 (existing) - RR50 - RR27 - Hwy. 140 - Netherby Rd. - Rusholme Rd. - Townline Rd. - Hwy.58 RR23 - O'Reilly's Rd.	-	5200	3
	QEW - RR24 - RR23 - O'Reilly's Rd.	-	4900	1 *
LF-3C	QEW - RR24 - Canborough Rd. - RR27 - Elcho Rd.	100	4950	9
	QEW - RR18 - RR69 - RR569 - Hwy. 20 - RR27 - Elcho Rd.	100	2200	1
	QEW - RR14 - RR714 - RR73 - RR14 - Hwy. 20 - RR27 - Elcho Rd.	100	3000	5
	QEW - RR14 - RR714 - RR73 - RR14 - RR16	-	3050	4
	QEW - RR12 - Hwy. 20 - RR27 - Elcho Rd.	100	2350	3
	QEW - RR12 - Hwy. 20 - RR14 - RR16	-	2400	2
	QEW - RR14 - RR81 - RR514 - RR14 - RR16	-	3950	6
	QEW - RR14 - RR81 - RR514 - RR14 - Hwy. 20 - RR27 - Elcho Rd.	100	3900	7
	QEW - RR24 - Hwy. 20 - RR27 - Elcho Rd.	100	4300	8 *
	* OMMC preferred			

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
LF-8C	QEW - RR24 - Hwy. 20 - Gee Rd.	-	4300	5 *
	QEW - RR24 - Canborough Rd. - Gee Rd.	-	4300	5
	QEW - RR18 - RR69 - RR569 - Hwy. 20 - Gee Rd.	-	2200	1
	QEW - RR14 - RR714 - RR73 - RR14 - Hwy. 20 - Gee Rd.	-	3000	3
	QEW - RR12 - Hwy. 20 - Gee Rd.	-	2350	2
	QEW - RR14 - RR81 - RR514 - RR14 - Hwy. 20 - Gee Rd.	-	3900	4
LF-9C	QEW - RR18 - RR69 - RR569 - Hwy. 20	-	2200	1
	QEW - RR14 - RR714 - RR73 - RR14 - Hwy. 20	-	3000	3
	QEW - RR12 - Hwy. 20	-	2350	2
	QEW - RR14 - RR81 - RR514 - RR14 - Hwy. 20	-	3900	4
	QEW - Vineland Twp. Rd. - Hwy. 20	-	4300	5 *
LF-1E	406 (existing) - RR50 - RR527 - RR27.	-	1100	3
	406 (proposed) - RR27	-	900	2
	QEW - RR47 - RR98 - Carl Rd.	-	150	1 *

* OMMC preferred

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
LF-3E	406 (existing) - RR50 - RR527 - RR27 - RR84 - Biggar Rd.	-	1100	3
	406 (proposed) - RR27 - RR84 - Biggar Rd.	-	900	2
	QEW - RR47	-	-	1 *
	* OWMC preferred			

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
PI-1N	401 - Hwy. 25 - Steeles - First Line	400	-	3
	401 - Hwy. 25 - Steeles - Tremaine Rd. - Britannia Rd.	-	350	2
	401 - Trafalgar Rd. - Britannia Rd.	-	5850	7
	401 - Fourth Line - Britannia Rd.	-	250	1 *
	QEW - Hwy. 25	-	1400	4 *
	QEW - Trafalgar Rd. - Britannia Rd.	-	2950	6
	403 - Winston Churchill Blvd. - Britannia Rd.	-	2650	5
PI-1N → LF-2N	Britannia Rd. - Trafalgar Rd. - Hwy. 401 - Hwy. 10	-	5850	4
	Britannia Rd. - Tremaine Rd. - Steeles - Hwy. 25 - Hwy. 401 - Hwy. 10	-	350	2
	First Line - Steeles - Hwy. 25 - Hwy. 401 - Hwy. 10	400	-	3
	Britannia Rd. - Fourth Line - Hwy. 401 - Hwy. 10	-	250	1 *
PI-1N → LF-4N	Britannia Rd.	-	-	1 *

* OMHC preferred

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
PI-27E	406 (existing) - RR50 - FF527 - RR27 - RR84 - Biggar Rd.	-	1100	3
	406 (proposed) - RR27 - RR84 - Biggar Rd. - RR47	-	900	2
	QEW - RR47	-	-	1 *
PI-27E +LF-1E	Biggar Rd. - RR98 - Carl Rd.	-	150	1 *
PI-27E +LF-3E	Biggar Rd.	-	-	1 *
PI-2W	403 - Hwy. 2 - Shaver Rd.	900	600	1 *
PI-2W +LF-4N	Shaver Rd. - Hwy. 2 - 403 - QEW - Hwy. 25 - Britannia	900	2000	1 *
	* OWMC preferred			

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
PI-2W +LF-10W	Shaver Rd. - Hwy. 2 - RR22 - Sawmill Rd.	900	1250	1 *
PI-2W +LF-11W	Shaver Rd. - Hwy. 2 - RR22	900	1250	1 *
PI-18E	406 (proposed) - RR27 - Hwy. 140	-	1100	1
	406 (existing) - RR50 - RR527 - RR27 - HWy.140.	-	1300	2 *
PI-18E +LF-3E	Hwy. 140 - RR27 - RR84 - Biggar Rd.	-	200	1 *
PI-18E +LF-1E	Hwy. 140 - RR27	-	200	1 *
	* OMMC preferred			

D-]

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
PI-18E → LF-1C	Hwy. 140 - Netherby Rd. - Rusholme Rd. - Townline Rd. - Hwy. 58 - RR23 - O'Reilly's Rd.	-	4100	1 *
PI-1A1	401 - Hurontario St. - Derry Rd. - Airport Rd.	-	-	1
	410 - Derry Rd. - Airport Rd.	-	-	1
	401 - Hurontario St. - Derry Rd. - Dixie Rd. - Steeles Rd. - Airport Rd.	-	-	1
	410 - Derry Rd. - Dixie Rd. - Steeles - Airport Rd.	-	-	1 *
PI-1A1 → LF-2N	Airport Rd. - Derry Rd.	-	-	1
	Airport Rd. - Steeles - Dixie Rd. - Derry Rd.	-	-	1 *
PI-13N	401 - Fourth Line - Derry Rd. - Fifth Line	200	-	2
	401 - Trafalgar Rd. - Britannia Rd. - Fifth Line	-	5600	6
	401 - Fourth Line - Britannia Rd. - Fifth Line	-	-	1 *
	QEW - Trafalgar Rd. - Britannia Rd. - Fifth Line	-	2950	5
	QEW - Hwy. 25 - Britannia Rd. - Fifth Line	-	1650	3 *
	403 - Winston Churchill Blvd. - Britannia Rd. - Fifth Line	-	2650	4
	* OMMC preferred			

D-1

Facility	Access Route	Sensitive Lands (m)		Ranking
		Local	Regional	
PI-13N → LF-4N	Fifth Line - Britannia Rd.	-	250	1 *
PI-13N → LF-2N	Fifth Line - Britannia Rd. - Fourth Line - Hwy. 401 - Hwy. 10	-	-	1 *
	Fifth Line - Britannia Rd. - Trafalgar Rd. - Hwy. 401 - Hwy. 10	-	5600	3
	Fifth Line - Derry Rd. - Fourth Line - Hwy. 401 - Hwy. 10	200	-	2

* OWMC preferred

APPENDIX E

SURFACE DRAINAGE EVALUATION

COMPARATIVE EVALUATION OF CANDIDATE SITES

SURFACE DRAINAGE

FOR

GARTNER LEE ASSOCIATES LIMITED

9464-01-0X01

JULY 1984

DILLON

Consulting Engineers & Planners

DILLON
Consulting Engineers & Planners

9464-01-0X01

OUR FILE:
YOUR FILE:

4 July 1984

Gartner Lee Associates Limited
Toronto-Buttonville Airport
Markham, Ontario
L3P 3J9

Attention: Mr. Gunther Funk

Site Selection - Phase 3
Hydrologic Evaluation

Dear Sirs:

We are pleased to submit our final report on the surface drainage aspects of the candidate sites. This report incorporates comments received from OWMC on our draft report.

We shall be pleased to discuss our report with you at any time.

Yours truly,

M.M. DILLON LIMITED

A.K. Mitchell

AKM:rp

A.K. Mitchell, P.Eng.
Project Manager

M. M. DILLON LIMITED – 47 SHEPPARD AVENUE EAST, TORONTO, ONTARIO • (416) 229-4646
MAIL: BOX 1850, STATION A, WILLOWDALE, ONTARIO, CANADA M2N 6H5 • TELEX 064-7540

TABLE OF CONTENTS

		PAGE
1.	METHODOLOGY	1
2.	SCOPE AND LIMITATIONS OF DATA	1
3.	INDICATORS OF THE SURFACE DRAINAGE FACTOR	2
4.	SITE SPECIFICS	3
5.	CONCLUSIONS	12

LIST OF TABLES

TABLE 1 - OWMC - SURFACE DRAINAGE EVALUATION

TABLE 2 - FACTOR RATING

COMPARATIVE EVALUATION OF CANDIDATE SITES
SURFACE DRAINAGE

1. METHODOLOGY

The work reported herein comprises feasibility level studies for siting of OWMC facilities relative to surface drainage. General suitability of alternative sites is considered in relation to surface drainage efficiency, potential drainage constraints and ease of implementing surface drainage controls, if required. Specific indicators considered include topographic relief, watercourse definition, baseflow, susceptibility to flooding, availability of local outlet works, and degree of difficulty for implementation of surface drainage controls.

Sites were evaluated by an experienced hydrologist using 1:10000 topographic base mapping and supplemented by a windshield survey of each site. Secondary source information, including flood plain mapping, was referenced, where available. In addition, where possible, sites were photographed during melt/runoff conditions (February 1984) to discern potential drainage/flooding problems.

2. SCOPE AND LIMITATIONS OF DATA

The current level of investigation is aimed at assessing the general suitability of the alternative sites relative to surface drainage.

No on-site investigations or other detailed analytical work was undertaken at this stage. Review of secondary source information, together with the windshield survey, permitted confirmation of general topographic and drainage features. No information has been reviewed to date relative to tile drainage of the sites.

Floodprone areas were estimated by airphoto interpretation and using existing flood plain mapping, where available. Further detailed work will be required on priority sites to more accurately establish flood susceptible areas and to define the required scope of on-site and/or off-site drainage works.

3. INDICATORS OF THE SURFACE DRAINAGE FACTOR

The sites have been evaluated on the basis of six parameters or indicators related to surface drainage. The significance of each of these indicators is briefly described below.

Topographic Relief: refers to the general slope of the site. Good surface drainage requires sufficient relief or slope to provide positive, efficient drainage. Relatively flat sites tend to be less well drained and to dry out more slowly (all other factors being equal). Moderate relief is preferred to provide efficient surface drainage without significant erosion.

On-Site Surface Drainage: describes the path which storm water takes to drain through the site and includes the overland flow path, together with swales and channels where flow is concentrated. Good drainage is characterized by an efficient, well developed, continuous network of swales and channels, draining all parts of the site. By contrast, surface depressions, with no apparent outlet, may remain wet for extended periods of time.

Upstream Drainage Area: relates to the potential quantity of water from upstream which has to be handled via watercourses passing through the site. Large upstream drainage areas are generally indicative of greater volumes of runoff and larger conveyance requirements, which may restrict siting of facilities.

Susceptibility to Flooding:	generally refers to the low lying areas adjacent to watercourses which flood periodically during spring melt and/or during periods of heavy, sustained rainfall. When large volumes of water are required to be handled, the potential for flooding normally increases and the conveyance systems may represent significant constraints to siting of facilities. Backup of flood water from off-site is also considered. Surface depressions, with no outlet or which are inefficiently drained, while not generally subject to significant flooding, may adversely affect site operations and require correction.
Availability of Outlet:	refers to the capability of watercourses and conveyance structures, both on-site and off-site, to conduct runoff away from the site. Inadequate outlets will require upgrading to mitigate adverse impacts.
Drainage Sheds:	relates to the potential for migration of contaminated runoff from the site. In the event of accidental contamination of surface runoff, confinement of the pollutants to a single watercourse (drainage shed) is preferred rather than spreading to multiple receiving bodies.

4. SITE SPECIFICS

A brief discussion of the individual sites is outlined below. Reference should also be made to Table 1 which describes the sites according to key drainage parameters. A summary factor rating for each site is provided in Table 2.

LF-10W

The site is characterized by good topographic relief varying from a high point of 214.5 m± El. in the northeast corner to approximately 206.5 m± near the outlet along the western and southern boundaries. The terrain is mildly rolling and is intersected by a number of shallow field swales which provide good surface drainage. All watercourses on the site are expected to be intermittent.

The site drains to two tributaries of Big Creek, which eventually discharge into the Grand River. Outlets along the southern and eastern sides of the site collect only local site surface drainage. The watercourse crossing the northwest corner of the site drains a larger upstream area including a small portion of site LF-11W.

The local drainage swales will be wet during periods of heavy rainfall/runoff. A narrow flood plain will be associated with the field swales, widening somewhat in the flatter portions of the site.

LF-11W

The site drains westward, southward and eastward via numerous drainage swales in the moderately rolling terrain. The highest topographic elevation (224 m±) is near the centre of the site; the lowest (210 m± El.) is located along the southern boundary and comprises flood plain lands along a tributary of Big Creek.

This site drains to two separate tributaries of Big Creek; the same two tributaries draining site LF-10W.

In general, the site is well drained. Some small wet pockets exist during wet weather. All drainage courses on the site are expected to be intermittent.

Drainage from the central and southern portions of the site could be readily directed, via perimeter ditching, to the watercourse along the south side of the site. This watercourse has a significant hydraulic capacity including a large concrete box culvert under Sawmill Road.

LF-1E

This site is very flat with topographic relief of only 1 to 2 m. The site is considered poorly drained with minimal evidence of on-site drainage swales or channels. Local ponding of water is expected throughout the site during wet weather. The land is expected to dry out slowly due to the heavy soils and absence of positive surface drainage features.

However, a tributary of Lyons Creek, along the southern edge of the site, appears to provide a good outlet for surface drainage and could readily facilitate improved drainage of the site, particularly the southern half. A narrow flood plain is associated with this intermittent watercourse. It may become necessary to confirm the extent of the flood plain by analytical methods since water levels exceeding the top of bank could flood a significantly larger area.

Another tributary of Lyons Creek drains a portion of the site to the northeast. Locally, this tributary comprises a shallow swale which may have to be upgraded both on-site and off-site to provide adequate surface drainage for the northern portion of the site.

LF-3E

The majority of the site is very flat with topographic elevations varying between 178 m to 179 m El. A shallow swale crosses the southern half of the site in a west-to-east direction providing the principal outlet for local surface drainage. This swale is tributary to Lyons Creek, which appears to provide an adequate outlet. Other north-south drainage swales connecting to small roadside ditches provide limited surface drainage.

In general, the site is poorly drained and is expected to contain wet pockets during wet weather. Some of these may be permanently wet resulting from poor surface drainage and heavy clay soils.

Some upgrading of drainage courses and local culverts, both on- and off-site, may be necessary to improve surface drainage.

LF-3C

The majority of the site is very flat with topographic elevations varying between 178 m and 180 m. Surface drainage is generally poor with numerous wet pockets observed during melt/rainfall periods.

Much of the site drains northward to Beaver Creek, a tributary of the Welland River. The Beaver Creek valley is shallow and quite wide, as is its flood plain. Valley flooding during the February melt in 1984 was increased due to ice blockage in the creek and particularly at the road culverts.

The southern portion of the site drains southeastward via shallow swales to another small tributary of the Welland River. The southeastern part of the site is very flat and is also subject to local surface ponding during wet weather.

Given the proximity of the site to significant natural drainage courses, improved surface drainage is feasible. However, the Beaver Creek flood plain represents a significant local constraint for siting of facilities and may need to be more accurately defined.

LF-8C

The site is characterized by flat to very gently rolling terrain varying in elevation from 185 m± in the north to 182 m± near the southern boundary. Drainage is generally from northeast to southwest via shallow field swales. Some of these swales may be discontinuous or at least poorly drained leading to isolated wet pockets.

Sucker Creek, located in a well defined valley on the west side of Gee Road, provides an adequate outlet for site drainage. The creek outlets to the Welland River a short distance to the south. Improvements would be required to the local site drainage including on-site drainage ditches and an appropriately sized outlet culvert under Gee Road.

LF-9C

The site is very flat with topographic elevations varying from 184 m± to 186 m±. Drainage is from north to south via very shallow field swales. Significant portions of the site are poorly drained and are subject to local ponding of water during wet weather.

Upgrading of both on-site and off-site watercourses may be required to improve site drainage. The existing outlet channel discharges to the Welland River, south of the site.

Should upgrading of the existing outlet prove impractical, it may be possible to divert site drainage a short distance to the east to the larger Sucker Creek watercourse.

LF-2N

The site is characterized by good topographic relief and is generally well drained. The highest topographic elevation of 201 m± occurs along a weak ridge through the western half of the site. From here the land slopes eastward, falling to elevation 192 m± along the eastern boundary.

The site is drained naturally by intermittent drainage swales in a generally southward direction. The ridge, which runs north-south, forms part of the boundary between two major watersheds. The western one-third of the site is drained by a tributary of Fletcher's Creek, which forms part of the Credit River watershed. The eastern portion of the site is drained by two small tributaries of Etobicoke Creek.

If necessaary, it appears feasible to drain the entire site to Etobicoke Creek.

LF-4N

The site is characterized by very flat relief, sloping gently from elevation 186 m± in the northeast corner to 182 m± in the southwest corner. It is moderately well drained with the exception of a permanent wetland in the southwest corner of the site. Other wet pockets may exist during wet weather because of the flat topography.

No significant drainage courses exist on-site. A very shallow drainage swale exists from the southeast corner, crossing Brittannia Road and discharging to a small tributary of Bronte Creek a short distance to the south.

Site drainage can be managed with local drainage improvements. Some off-site channelization may be required, subject to further study, to provide an adequate outlet to the south. Alternatively, diversion to the west along Brittannia Road to a much larger tributary of Bronte Creek is feasible.

LF-1C

The site is extremely flat with no perceptible relief. Shallow roadside ditches border two sides of the site and a very shallow swale runs north-south across the site. Otherwise, there is no evidence of surface drainage features and no adequate outlets were identified in the field.

The site is very poorly drained and is expected to contain numerous wet pockets during wet weather. Some of these may be permanently wet due to poor surface drainage and the presence of heavy clay soils.

Poor surface drainage may severely limit site potential in the absence of an adequate outlet. Based on existing flood plain mapping of the Welland River in the vicinity of the site, construction of a suitable outlet appears feasible. The site should not be flooded by backup from the Welland River.

PI-1A1

The site is well drained with adequate relief for overland flow (e.g. 3 to 4 m across site). A small intermittent drainage swale crosses the site from northwest to southeast leading to a tributary of the West Humber River above the Clairville Reservoir.

The site is not susceptible to flooding and is rated good for surface drainage.

PI-1N

The site area is fairly flat with a gentle slope toward very shallow field swales. Depending on the specific location of the site, these swales connect to small tributaries of either Bronte Creek or Sixteen Mile Creek. The drainage divide between the two creeks runs through the most northerly of the two site options.

Subject to more detailed investigations, some minor upgrading of local surface drainage works may be required to overcome the flat topography. No significant problems are anticipated with this site relative to surface drainage.

PI-18E

The site is very flat and poorly drained. Surface drainage exits the site via a shallow field swale and concrete box culvert under Highway 140. The outlet swale discharges to Lyons Creek a short distance northeast of the site and ultimately to the Welland River.

The site will be subject to periodic surface ponding during wet weather. However, the existing outlet will permit upgrading of surface drainage on-site. Consequently, surface drainage does not represent a significant constraint for this site.

PI-2W

The site is characterized with significant relief, comprising low hummocks and intersected with a dense pattern of narrow field swales between. Surface drainage is very efficient and the site will probably dry out quickly after rainfall.

The local field swales have sufficient capacity to carry local drainage and are characterized by very narrow flood plains. The site drainage is tributary to Big Creek and the Grand River.

Surface drainage does not represent a constraint for this site. However, facilties would have to be strategically located away from the drainage courses, which cannot be readily relocated in this terrain.

PI-27E

This site is flat to gently rolling and appears fairly well drained. The average site elevation ranges between 177 m± to 178 ± and slopes gradually to two creeks running west to east through the property. The flattest portions of the site will be subject to surface ponding during wet weather.

The two creeks traversing the site, Grassy Brook and Tea Creek, outlet to the Welland River east of the site. Both outlets appear adequate for local site drainage. The flood plains of the creeks appear relatively narrow and well defined.

No significant surface drainage problems are anticipated with this site.

PI-13N

The site is characterized by gently rolling terrain with sufficient relief to provide positive surface drainage. Topographic elevations across the site range from 193.5 m± to 188.5 m±, with surface drainage flowing generally north to south.

Three small tributaries of Sixteen Mile Creek provide good local drainage with adequate outlets. Sixteen Mile Creek, which flows near the east boundary of the site, is confined within a significant valley and is not expected to flood the site. The Halton Region Conservation Authority is currently preparing flood plain mapping for Sixteen Mile Creek. However, preliminary results are not yet available.

The minor watercourses on-site will have a narrow flood plain associated with each. Some of the small tribuaries in the area are designated as hazard lands in the Milton Official Plan, possibly due to the steep valley slopes. Surface drainage does not represent a constraint to this site.

5. CONCLUSIONS

A number of the sites under consideration are considered well drained in their natural state, with no on-site or off-site constraints. Minimal, if any, modifications would be required to improve local drainage. Adequate outlets are generally available with no significant potential for serious flooding. These sites include LF-10W, LF-11W, LF-2N, LF-4N, PI-1A1, PI-2W, PI-27E, and PI-13N.

Several other sites investigated are moderately constrained due to poor local surface drainage and/or substantial flood plain areas. However, local upgrading of surface drainage is possible with acceptable outlet capacity in the vicinity. Sites in this category include LF-1E, LF-3E, LF-3C, LF-8C, LF-9C, PI-1N, and PI-18E.

Only site LF-1C may be severely constrained from a surface drainage perspective. It combines very poor local surface drainage with the absence of an adequate outlet to facilitate local drainage improvements.

Based on available flood plain mapping provision of an adequate outlet appears feasible. However, this would require a structure under the Welland Station railway yard, together with a new outlet to the Welland River.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
LF-10W	good topographical relief across site; mildly rolling terrain which flattens out in SE corner	well drained via shallow drainage swales; probably intermittent	small; swale across NW corner drains from site 11W	minimal; local drainage swales may have narrow flood plain	numerous outlet swales draining to two separate tributaries of Big Creek	two tributaries to Big Creek and Grand River	Site rated Level 1 for surface drainage; probably necessary to use both major local tributaries as outlets.
LF-11W	good topographic relief throughout site; moderately rolling land with continuous and well defined drainage courses	well drained; numerous minor swales drain in all directions from high point of land in centre of site	small	major tributary to Grand River has readily defined flood plain which may encroach on site on SE side	numerous minor outlet swales with good slope; largest tributary to south	two major tributaries to Big Creek and Grand River	Site rated Level 1 for surface drainage for landfill; if necessary majority of site, with exception of northerly portion, could be drained to largest outlet tributary on south and east side via perimeter ditching.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
LF-1E	very flat; minimal relief	poor surface drainage; potential for isolated wet pockets on site; only local drainage channel of significance is Lyons Creek on south edge of site	upper tributary of Lyons Creek	narrow flood plain adjacent to Lyons Creek; site may have local wet pockets	major outlet to south via Lyons Creek; appears generally adequate; small local drainage swale to north- [illegible] to another [illegible] tary of Lyc Creek	two locally, both tributary to Lyons Creek	Site considered Level 2 for surface drainage for landfill; site limitations may be overcome by upgrading local drainage works outletting to Lyons Creek.
LF-3E	very flat; minimal relief	poor surface drainage; limited local drainage channels/swales; shallow roadside ditches with poorly defined outlets	relatively small locally	potentially wet much of year; local wet pockets; extent of flood plain difficult to define; shallow drainage swales through site will have local flood plain associated with each	outlet via local tributary of Lyons Creek; outlet appears adequate; possibly some upgrade off-site	one only	Site considered Level 2 for surface drainage for landfill; site limitations may be overcome with upgraded drainage works discharging to Lyons Creek tributary.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
LF-3C	flat to gently rolling terrain	appears poorly drained; numerous wet pockets during wet weather; Beaver Creek valley shallow with wide flood plain	upper portion of Beaver Creek	Beaver Creek flood plain is quite wide; local surface ponding throughout site during wet weather	good natural outlets via Beaver Creek and Welland River	two locally; Beaver Creek and Welland River	Site rated Level 2 for surface drainage; relative flatness of site is offset by good natural outlet(s) in immediate vicinity.
LF-8C	flat to very gently rolling	moderately well drained; potentially discontinuous swales with isolated wet pockets; sufficient relief overall to drain efficiently to Sucker Creek	locally very small	minimal; potential for local wet pockets	Sucker Creek provides well defined outlet on west side of Gee Road; improved outlet to Sucker Creek will be required	one only; Sucker Creek	Site rated Level 2 for surface drainage; local wet pockets may need to be controlled; good local outlet.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
LF-9C	flat to very gently rolling	poorly drained; shallow swales crossing site; numerous wet pockets with poor local drainage	small locally	central drainage swale probably has narrow flood plain; numerous local wet pockets	shallow field swale provides main natural outlet; may require some upgrading off-site; alternatively, entire site could possibly be drained directly to larger Sucker Creek watercourse	two locally	Site rated Level 2 for surface drainage; flatness of site may be offset by improved on-site and outlet drainage works.
LF-2N	good relief for surface drainage	adequate; site drained by three narrow drainage swales; well drained; local tributaries intermittent	very small	NIL	adequate; shallow swales may need to be improved locally to provide adequate outlet for landfill site	two; west 1/3 of site drains to Fletcher's Creek and Credit River; east part drains to Etobicoke Creek	Drainage divide on-site could be concern; appears practical to drain entire site to Etobicoke Creek; site rated Level 1 from surface drainage perspective

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
LF-4N	site appears fairly flat, but has adequate relief for surface drainage	site appears moderately well drained with exception of wetland area in southwest corner; site drains generally from NE to SW	small	wetland in SW corner will be subject to periodic flooding and may be continually wet	on-site drainage courses are very limited; tiny drainage swale in SE corner may not be adequate for site drainage without substantial upgrading; may be preferable to provide improved outlet to west via largest tributary	one only; tributary to Bronte Creek	Site rated Level 1 for surface drainage for landfill site; off-site works may be required to provide adequate outlet to Bronte Creek.
LF-1C	very flat; minimal relief	poor surface drainage; minimal evidence of local drainage channels/swales or outlets; potential for wet pockets throughout site	probably small locally	potentially wet much of year; extent of flood plain difficult to define in this terrain	existing outlet undefined; appears feasible to provide new outlet to Welland River to drain this site.	locally unidentifiable	Site considered Level 3 for surface drainage; site limitations may be difficult to overcome even with outlet improvements.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
PI-1A1	good; on high land at up-stream end of small drainage swale	adequate relief for overland flow; well drained; local drainage swale probably dry most of time	very small	NIL	adequate; shallow swale could be deepened, if necessary, to improve capacity of outlet channel immediately adjacent to site	one only; tributary to West Humber River	Clairville Reservoir downstream; site rated Level 1 from surface drainage perspective
PI-1N	site fairly flat; mild gradient to off-site drainage swales	adequate relief to ensure reasonable site drainage; local tributaries intermittent	very small	minimal	mildly sloping shallow swale to south/east is tributary to Bronte Creek; to north tributary to Sixteen Mile Creek; outlets may require up-grading off-site	potentially two; tributary to Bronte Creek and/or Sixteen Mile Creek, depending on specific location of site	site rated Level 2 for surface drainage for phys-chem-incinerator facility
PI-1BE	very flat; minimal relief	poorly drained; shallow swale and culvert under Highway 140 provides outlet to Lyons Creek	very small	site may remain wet after rainfall due to flat topography, impermeable soils and inefficient local drainage	available outlet via small tributary of Lyons Creek; could be upgraded locally, if required	one only	Site considered Level 2 for surface drainage for phys-chem-incinerator facility; local drainage may be improved to facilitate adequate drainage.

TABLE 1
O W M C - SURFACE DRAINAGE EVALUATION

REF. NO.	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE SURFACE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMMENTS
PI-2W	good topographical relief across site; low hummocks with narrow flood plain between	well drained; local swale drains through centre of site; intermittent	very small	minimal; local drainage swales should be maintained with narrow flood plain	local swales should provide adequate outlet with minimal upgrading	one only; tributary to Big Creek and Grand River	Site rated Level 1 for surface drainage.
PI-27E	flat to gently rolling	appears fairly well drained with land falling gently to creek; adequate relief for good surface drainage via defined intermittent creeks	very small	two creeks traversing site probably have narrow flood plains generally confined to width of 15 m to 25 m; minor surface ponding on flat portions of site	appears to have adequate outlets to Welland River; flood levels in Welland River will not affect levels on-site; Welland River flood level confined within banks in this vicinity	two locally; Grassy Brook and Tea Creek both outletting to Welland River	Site rated Level 1 for surface drainage; good local outlets.
PI-13N	good relief for positive surface drainage	generally north to south; via three small tributaries of Sixteen Mile Creek; local tributaries intermittent	local only	minimal; narrow flood plain associated with minor watercourses on-site; Sixteen Mile Creek confined in valley	good; three tributaries of Sixteen Mile Creek	one only; Sixteen Mile Creek	Site rated Level 1 for surface drainage.

TABLE 2
FACTOR RATING

SITES	TOPOGRAPHIC RELIEF	ON-SITE DRAINAGE	U/S DRAINAGE AREA	SUSCEPTIBILITY TO FLOODING	AVAILABILITY OF OUTLET	DRAINAGE SHEDS	COMPOSITE RATING
LF-10W	good	good	good	good	good	fair	Level 1
LF-11W	good	good	good	good	good	fair	Level 1
LF-1E	poor	poor	good	fair	good	good	Level 2
LF-3E	poor	poor	good	fair	good	good	Level 2
LF-3C	fair	poor	fair	poor	good	fair	Level 2
LF-8C	fair	fair	good	fair	good	good	Level 2
LF-9C	fair	poor	good	fair	fair	fair	Level 2
LF-2N	good	good	good	good	fair	fair	Level 1
LF-4N	good	good	good	fair	fair	good	Level 1
LF-1C	poor	poor	good	poor	poor	undefined	Level 3
PI-1A1	good	good	good	good	good	good	Level 1
PI-1N	fair	good	good	good	fair	fair	Level 2
PI-18E	poor	poor	good	fair	fair	good	Level 2
PI-2W	good	good	good	good	good	good	Level 1
PI-27E	good	good	good	good	good	fair	Level 1
PI-13N	good	good	good	good	good	good	Level 1